COMBUSTION

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Boiler Test, East River Station, New York Edison Company
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COMBUSTION

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COMBUSTION

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Mergers of Men and Equipment

W. R. WOOD

THERE is a force, arising out of economic necessity, driving us to larger units and to the mergers of such units. This force is not new. When man worked by hand alone, his production was individualistic, usually in his home. With the discovery of the steam engine men grouped together to take advantage of the power thus available. When railways and steamships were developed the merging of both human and mechanical energy gained momentum because men with organizing genius could communicate quicker and reach further with their abilities. But it remained for the automobile, the telephone and the airplane to furnish means for the tremendous expansion of this driving force, to the degree that has become manifest in the present wave of mergers here and in European countries.

While some opinions are voiced indicating apprehension or even fear of disastrous consequences to society by large consolidations of business capital, there seems, nevertheless, to be a strong undercurrent of conviction that these mergers are a natural evolution in the business structure and are, therefore, productive of much good. It is rather clearly recognized that the basic incentive for mergers is increased economy in the conduct of business and that this economy is, by force of competition, necessarily passed along to the ultimate consumer.

This movement is felt in the engineering development of equipment used in the production of power. Small units for steam production and for steam utilization are fast being supplanted by the power station with its mammoth steam generating boilers and steam turbine generators now so common in the central power stations. Steam generating units of 50,000 lb. per hour capacity ruled as favorite some years ago—today 800,000 lb. per hour is considered practical for a single steam generating unit. Turbines of 15,000 kw. capacity were, but a short time ago, considered large enough for a single unit—today 150,000 to 200,000 kw. are produced from a single turbo-generator.

The development in size of this equipment is comparable with the development in size of business organizations. The larger units in both equipment and business have come to be an economic necessity because they save money. Exactly the same forces have been at work in both fields, with similar results, and unquestionably in both developments there is a definite benefit to the social structure which they serve and which in turn has furnished the broad basis of their evolution.

W R Wood

Senior Vice President
International Combustion Engineering Corporation

EDITORIAL

Power Plants are not Mystery Plants

THE non-technical managers of many industries often regard their power plants as too mysterious and technical for them to understand in the same intimate way that they understand the equipment of their manufacturing plants. The complications of such equipment as paper machines and rolling mills, or the complicated processes of soap making, textile manufacturing, and the infinite field of chemical manufacturing, do not find the manager helpless. He is invariably conversant with the details involved in his product manufacturing problems. There is no adequate reason why he should be faced down by his power manufacturing problem.

A power plant is exactly like any other manufacturing unit. There are three major raw materials, and usually either one or two major products. The power plant manufactures either steam or electricity, or both. Coal and water are the principal raw materials and the other one is air. The cost of coal and water is definite, while the cost of air is indefinite. Of course, other items of cost, such as repair parts, lubricants, tools, labor, overhead and fixed charges, enter into the total cost of the power product, just as they enter into the cost of any other product.

To be sure, the manager usually does not know how, with his own hands, to use the power plant equipment for making the raw materials into the final products, but neither does he know how to accomplish, with his own hands, many other processes in his establishment. He may be incapable of adjusting the countless controls on the paper machine, of operating the rolling mill, of judging when a batch of soap is finished, or of expertly attending the textile machinery.

But he does know when the finished product is up to market standards, and he does know whether his costs of production are reasonable. He is competent to recognize improved methods, and to initiate them. Above all, he is usually skillful in handling the personnel of an organization.

The intelligence necessary to execute the duties of the managerial position is entirely adequate for comprehending the manufacturing problems of the power plant. The same systematic control, through daily reports of quantities and costs, that enables the manager to maintain economical production of his saleable product, will also enable him to control his power production. Only a small amount of technical advice is needed to show him whether the amount of product can be increased from a unit amount of raw material, and no extraordinary effort will be required to put the advice into practice.

Nothing is to be gained by the manager in showing a lack of personal interest in the working of his power plant simply because he does not know all the technique of power production. Much is to be gained, on the other hand, by intelligently applying himself to his power production problem in exactly the same way that he applies himself to the other manufacturing problems for which he is responsible.

Test Results that Record Daily Performance

TESTS of boiler plants, for the purpose merely of establishing records, are passing out of fashion. When new and often radical ideas for heat generation and for heat absorption were coming on the market, one after another, it was natural and entirely fitting that owners and manufacturers alike should widely herald their new and higher achievements in thermal efficiency. Eight hour boiler tests were deemed sufficient proof of the resultant figures, and twenty-four hour tests were considered as superlatively certain of accuracy.

This was true, but the results were for test conditions only, and these conditions were not generally duplicated in daily operation, nor, consequently, were the record efficiencies duplicated. With the consolidation of the newer equipment in the hands of carefully trained operating staffs, there has come about a very high level of daily operating efficiency in the leading central stations. Tests for these organizations no longer are run to establish peaks of performance, but accurately to record daily practice. The difference today between tests and regular operation in such a plant consists merely in the fine measurement of those quantities which are required for a heat balance study of the operation, and which constitute a close check on the accuracy of the measurements themselves. The object is to ascertain the thermal efficiencies and the economies of regular operation.

The series of three seventy-two hour tests on a large steam generating unit, described in a feature article in this issue, are noteworthy because their results are of this new order. The high efficiencies and the high ratings secured are not peaks of supreme limit, reached by extraordinary grooming of the equipment, but are measures of the high level of operation to which the station has developed. The entire report is thus a document of more than ordinary value to both the engineers of the plant in which the tests were run, and the engineering public to which they have been released.

Test *of* Boiler No. 4, East River Station, The New York Edison Company

By W. H. Lawrence
Chief Operating Engineer, The New York Edison Company

532 per cent rating for 72 hours is a noteworthy performance in boiler plant operation. Mr. Lawrence's article not only records these figures but also shows that this operation was secured with equipment several years old, and with conditions not 100 per cent favorable to top-notch performance. The tests will be used for comparison in the near future with similar tests of new equipment in this same central station.

THE expansion of the East River Station has involved the installation of new equipment which differs markedly in size and detail from the older equipment, although in both cases the equipment was selected to meet the practical demands of economy then existing. The difference in these demands is, however, rather sharply marked over an interval of even a very few years. Thus, in 1926 boilers of about 1500 hp. were installed, whereas the steam generating units now being installed will have an expected capacity of 800,000 lb. of steam per hour, or possibly even more.

It was desired to get an accurate comparison of performance levels of both installations, and for this purpose a series of tests were undertaken on the 1926 equipment for direct comparison in the future with similar tests that will be run on the new equipment. No. 4 boiler was selected and evaporative tests, each of 72 hours duration, were run at capacities of 108,000, 170,000 and 240,000 lb. of steam per hour.

The No. 4 unit consists of a Springfield boiler with Elesco interdeck superheater, and Combustion Engineering Corporation plate type air preheater and Lopulco storage system for pulverized coal firing. The furnace is formed with fin tube walls on four sides and fitted with bottom screen tubes.

Both forced and induced draft are supplied by individual Sturtevant fans driven by Sturtevant turbines. The primary air is taken from a duct which is common to all boilers but with individual damper control at each boiler. One quarter of the air preheating surface is used for heating the primary air which enters the duct common to all of the boilers. The other three quarters of the air preheater is used for heating the secondary air for the individual boiler with which the air preheater is connected.

The pulverized fuel equipment for each boiler includes a bin of 100 tons capacity and this storage supplies 10 feeders, which in turn supply 10 vertical burners and 10 auxiliary horizontal burners. The fuel feeders are motor driven and speed control is obtained through individual motor generator sets.

Details of heating surface and furnace volume are given in Table I.

The tests were conducted with great care for practical accuracy. Coal was weighed and frequent samples taken for analysis. Water was measured with carefully calibrated Venturi tubes, and temperatures were recorded by means of thermocouples and potentiometer. The principal results are shown by the curves of Fig. 1 and by reference to the complete heat balance in Table II. An efficiency of 87 per cent for the 72 hour run at over 300 per cent rating (including water walls), was obtained. The ability of the unit to carry high ratings over a period of time was impressively demonstrated by the capacity test, which showed an average boiler rating of 416 per cent, including water walls, or 532 per cent, excluding water walls, for 72 consecutive hours.

TABLE I

Boiler heating surface	14809	sq. ft.
Water wall heating surface	4134	sq. ft.
Total heating surface	18943	sq. ft.
Superheater surface	3430	sq. ft.
Air preheater surface	28900	sq. ft.
Furnace volume, above water screen	15888	cu. ft.
Furnace volume, above water screen per sq. ft. of total heating surface	0.84	cu. ft.

The coal was weighed in 2 10-ton weigh bins, and then discharged through a separate and individual line to the 100-ton bin of No. 4 boiler. The test was started and stopped with a small and equal quantity of coal in the 100-ton bin, just sufficient to maintain a steady fire. Samples for moisture and analysis were taken from each ton of coal burned. A composite sample was made for each twelve hours and analyzed. Separate samples were taken for moisture analysis.

The quantity of water fed to the boiler was determined by means of two Venturi tubes and mercury manometers, manufactured by the Simplex Meter Company. The Venturi tubes were calibrated with weighed water, and the correction factor determined. Minute readings of the mercury manometer were taken throughout the 72 hours of each test.

All temperature readings necessary for the determination of the heat balance were taken by means of thermocouples. Ten thermocouples were used in each of the gas and air connections to and from the air preheater. Readings were taken every fifteen minutes.

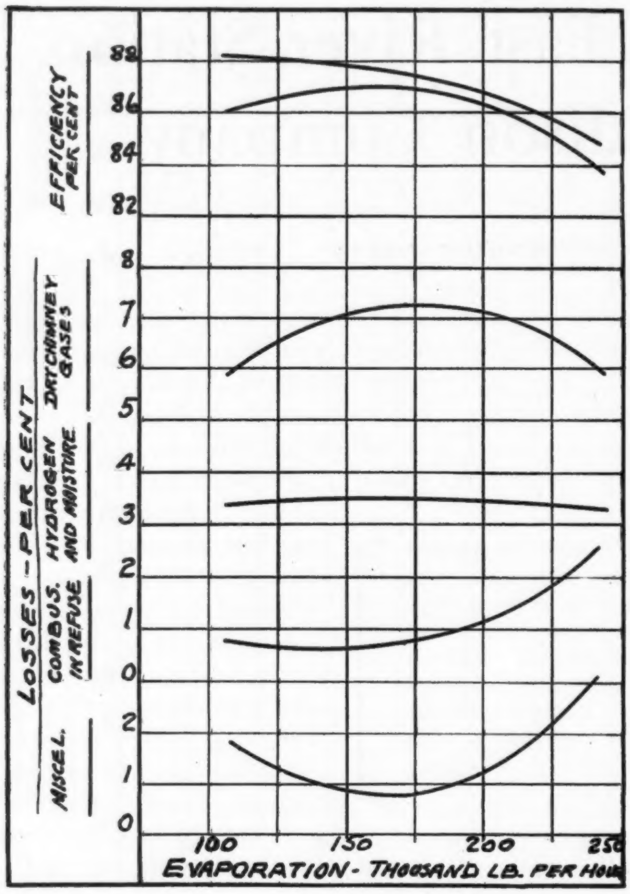


Fig. 1—The heat balance quantities of Table II plotted as curves

Four flue gas sampling pipes were located at the boiler and air preheater outlets. Readings were taken at each point every half hour.

Samples of fly ash were obtained by passing some of the flue gas through a cinder collector. A check was also made by taking samples of the cinder caught in the cyclone cinder catcher, and of the cinder escaping to the stack. Samples of refuse from the ash pit were taken each time the ash pit was cleaned.

As previously stated, one quarter of the air preheater surface is used to heat primary air from No. 2-A primary air fan. This fan supplied more

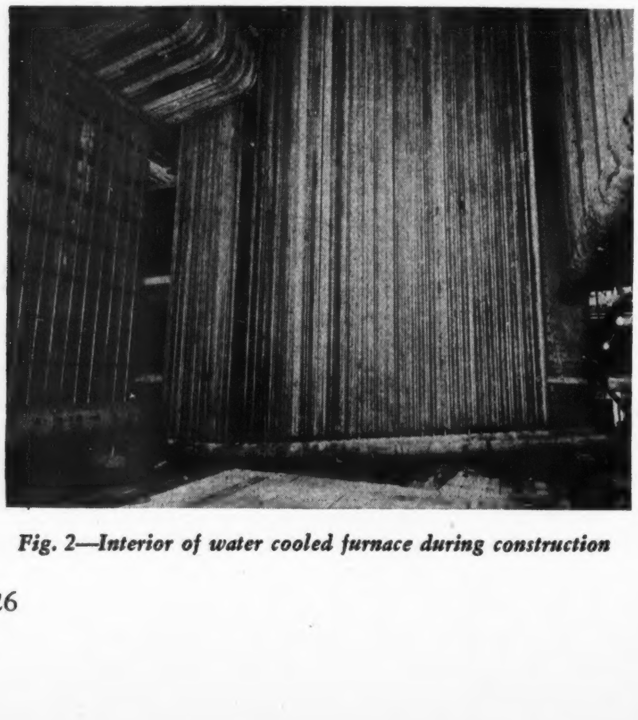


Fig. 2—Interior of water cooled furnace during construction

primary air than was required by No. 4 boiler. The primary air leaving the air preheater enters a duct common to all boilers, and all primary air fans. It is necessary, therefore, in order to make a heat balance, to determine the quantity of primary air entering the boiler. This was determined by pitot tube measurements. In all three tests, more primary air was passed through the air preheater than was used by No. 4 boiler.

Owing to operating conditions it was necessary to run No. 4 boiler on coal milled by the screen mills during the run at maximum rating. This coal was

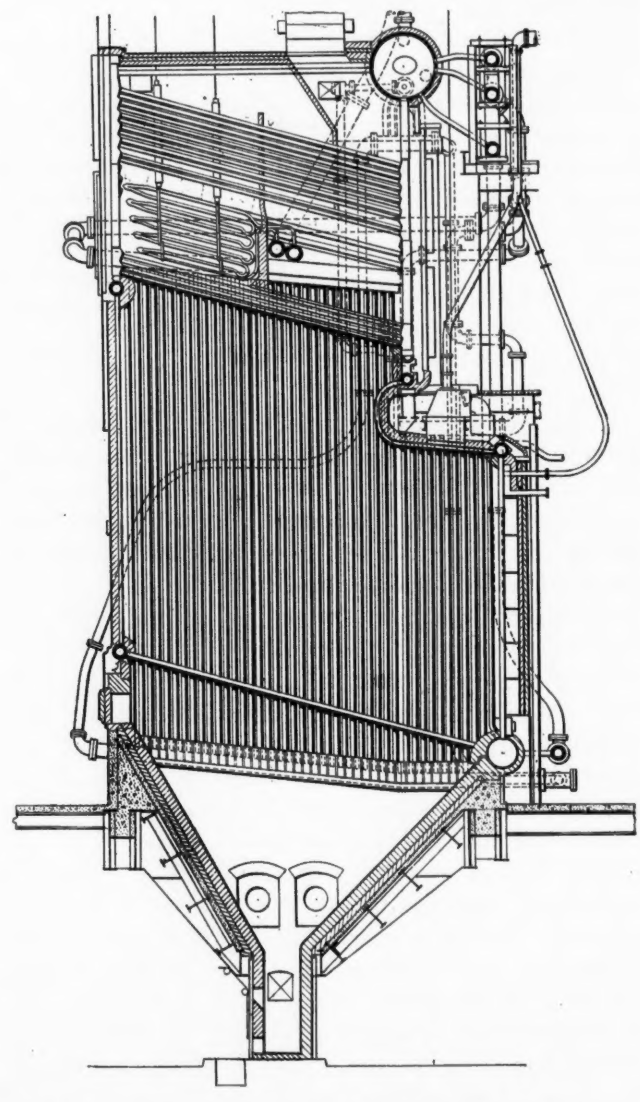


Fig. 3—Side sectional elevation of the complete unit, the performance of which is recorded by these tests

very coarse and caused a high combustible loss. Previous determinations would indicate a combustible loss of about 1.5 per cent with coal of satisfactory fineness.

The storage coal used for the other two tests, due to burning and oxidation while in storage, had lost considerable of its active volatile content and still better results could have been obtained if fresh coal had been available at the time of the test.

TABLE II

		April 23, 1929	May 7, 1929	May 14, 1929
Actual evaporation per hour	lb.	108630	169100	239720
Heat absorbed by steam	per cent	86.1	87.1	84.1
Heat absorbed by air preheater and returned to other boilers	per cent	2.0	0.5	1.0
Heat loss due to moisture in coal	per cent	0.2	0.3	0.2
Heat loss due to moisture in burning hydrogen	per cent	3.2	3.2	3.1
Heat loss due to dry chimney gases	per cent	6.0	7.3	6.1
Heat loss due to combustible in refuse	per cent	0.8	0.8	2.5
Heat loss due to radiation and unaccounted for	per cent	1.7	0.8	3.0
Total	per cent	100.0	100.0	100.0

TABLE III

		April 23, 1929	May 7, 1929	May 14, 1929
Actual evaporation per hour	lb.	108630	169100	239720
Boiler horsepower		3545	5715	7885
Per cent rating (including water walls)		187	302	416
Per cent rating (excluding water walls)		240	386	532
Steam pressure, boiler-gage	lb. per sq. in.	404	414	425
Steam pressure, superheater outlet	lb. per sq. in.	398	399	400
Steam temperature	deg. fahr.	685	711	710
Air to air preheater	deg. fahr.	106	108	111
Average temperature of gases leaving air preheater	deg. fahr.	328	382	368
Temperature feed water	deg. fahr.	293	294	298
Fuel, as fired per hour (weighed)	lb.	10030	15650	22200
Fuel, dry per hour	lb.	9740	15060	21800
Combustion space per lb. dry coal	cu. ft.	1.63	1.05	0.73
Actual evaporation per lb. dry fuel	lb.	11.15	11.23	10.99
Actual evaporation per lb. fuel as fired	lb.	10.82	10.80	10.80
Factor of evaporation		1.126	1.137	1.135
Equivalent evaporation per lb. dry fuel	lb.	12.48	12.76	12.47
Thousands B.t.u. absorbed per hour		118730	186520	263810
Thousands B.t.u. absorbed per sq. ft. boiler heating surface including water walls		6.27	10.40	14.37
Refuse, per cent of fuel, dry		9.1	8.7	10.4
Per cent combustible in ash to ash pit		1.0	0.8	2.1
Per cent combustible in fly ash		9.7	10.0	25.8
Per cent combustible in refuse		8.8	9.1	23.3

TABLE IV

		Semi-Bituminous Storage	Semi-Bituminous Storage	Semi-Bituminous Fresh Mined
Proximate analysis dry:				
Volatile matter	per cent	18.8	19.2	19.5
Ash	per cent	8.3	7.9	8.0
Fixed carbon	per cent	72.9	72.9	72.5
Moisture—as fired	per cent	2.9	3.8	1.9
Heating value per lb. dry	B.t.u.	14140	14220	14410
Ultimate analysis:				
Carbon	per cent	80.65	80.60	80.70
Hydrogen	per cent	4.25	4.28	4.29
Oxygen	per cent	4.70	5.22	4.38
Nitrogen	per cent	1.25	1.22	1.25
Sulphur	per cent	6.89	0.78	1.36
Ash	per cent	8.28	7.90	8.02
Fineness:				
Through 60 mesh screen	per cent	92	95	80
100 mesh screen	per cent	85	89	69
200 mesh screen	per cent	72	73	54

The mine plant at Moundsville, West Virginia

The Hayes Process Low Temperature Carbonization Plant *at* Moundsville, W.Va.

By J. D. McQuade
Coal Carbonization Company, Pittsburgh, Pa.

Low temperature carbonization has come to the assistance of a bituminous coal mine property as an economic aid in reclaiming a waste fuel, and turning a loss into a profit. This installation is a practical commercial success, the theoretical and experimental stages having been definitely passed. The article is the complete paper delivered by Mr. McQuade at the Fuels Meeting of The American Society of Mechanical Engineers in Philadelphia in October, 1929.

THE primary reason for undertaking the development of a low-temperature carbonization process at Moundsville was to provide a means whereby the slack coal or screenings, which constitute from 30 to 40 per cent of the output of the mine, could be changed into a fuel that could be sold at a profit.

It is unnecessary to go into detail regarding the troubles which for the last five years have beset the coal industry, as they are generally known. However, the company became convinced that if it had an outlet for the screenings, through which they could be sold at a price above the cost of production, the prepared sizes of coal could be sold on the open market at a price that would justify the continued operation of the mine.

With this object in view, a thorough investigation was begun of the different processes having for their object the utilization of low form value screenings. Many schemes were investigated, which ranged from various methods of cleaning and preparing the coal to the various methods of carbonizing the coal at low temperatures. Some of these processes were installed and operated on a small scale, only to be discarded because of high installation and operating costs or because the finished product was not in a suitable form for domestic use.

As a result of these investigations, the company was thoroughly convinced that low-temperature carbonization offered the most satisfactory and most profitable means of changing the form value of bituminous-coal screenings, provided a process could be found that met with the following requirements:

1. It must be a machine capable of continuous operation over reasonably long periods and be free from difficulties due to carbon formation and sticking when operating on high-volatile bituminous coals.
2. The retorts must be of such design that permit necessary replacement and repairs to be effected in the shortest possible time and with a minimum of labor.
3. The process must be automatic or nearly so in its operation so as to reduce the amount of labor

and supervision to the lowest possible figure.

4. The process must be of such a type that the entire solid product could be recovered in a form suitable for use as a high-grade domestic fuel and in such form that it would stand the abuse of handling and shipping with the least amount of degradation.
5. It must yield a large amount of tar oils of such characteristics that have the highest market value and at the same time yield a gas of high heating value.
6. The initial investment cost per ton day input of coal must be sufficiently low to allow the fuel product to be sold in competition with existing fuels and at the same time realize a substantial return on the investment.

With these objectives in mind, and after many tests on small scale retorts, the patent rights for the Hayes process were purchased in 1926. In 1927 the first full-scale unit was built, having a capacity of 50 tons of coal input per 24 hours.

With the operating experience and data obtained from this unit as a basis to work on, a second unit of 50 tons capacity was constructed in which many improvements were incorporated. This unit has been in successful commercial operation up to date.

The Hayes process retort consists of an alloy steel tube 17 in. inside diameter by 20 ft. long. This tube is placed in a furnace setting and supported by rollers on each end. Stationary feed and discharge castings are located at either end of the retort and are connected to it by special packing rings. The tube is rotated at a speed of 1½ revolutions per minute.

Within the retort is a specially constructed screw conveyor. This screw is driven by a train of gears which gives it a progressive oscillating motion. The motion is such that the screw moves the coal toward the discharge end of the retort a given distance, and on the reverse oscillation it is returned a distance slightly less than the forward motion. Due to this forward and backward motion, the coal has a theoretical travel of 240 ft. in passing through the length of the retort.

The problem of coal carbonization resolves itself into a question of heat transfer. In low-temperature carbonization, due to the relatively low heat head available, it is difficult to raise the temperature of a layer of coal to the point where complete distillation is effected in a reasonable length of time. In this process, due to the motion of the retort screw, every particle of coal is brought into contact with the hot walls of the retort, and the carbonization is completely effected in the short time of 25 minutes.

In the present unit, seven of these retorts are located in a battery type of furnace. Each retort is heated externally by means of gas burners located on the under side of the furnace, and each retort is entirely independent of the operation of the other six. Removable one-piece covers form the top of the furnace, and any retort can be removed for inspection or repairs without interfering with the operation of the other six.

Coal is fed to each of the retorts by a screw feeder located on the feed end casting. The rate of feed is 700 lb. per hour for each retort.

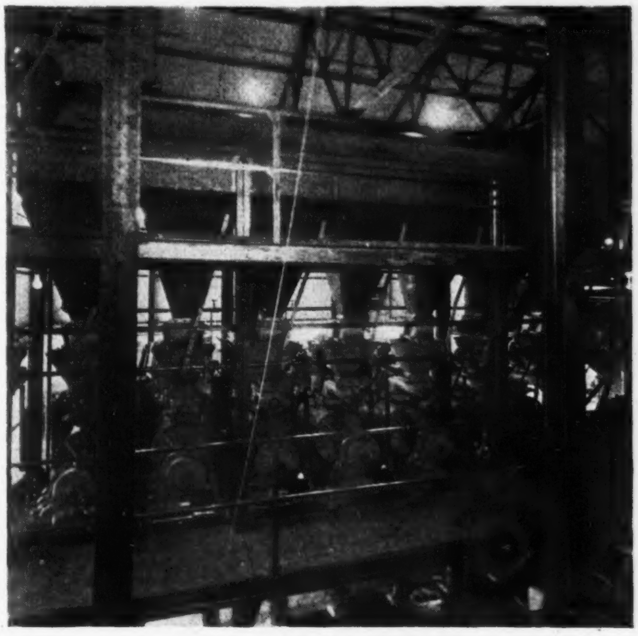


Fig. 1—Assembly of feed end of low temperature carbonization retorts

The char is discharged from each retort into a main collecting conveyor, which runs the length of the retort setting, thence being discharged into a quenching conveyor, where it is cooled by water sprays. From this conveyor the char discharges through a rotary seal valve and is conveyed to a crusher, where it is ground to the proper size for briquetting.

The coal gas and tar vapors are removed from the retorts through offtake connections located at either the feed or discharge end of the retorts and are conducted through standard condensing and cleaning apparatus, where the tar is removed and the gas is sent to the holder.

In this installation the gas produced is returned to the furnaces and is used for heating the retorts, and the excess gas is used for steam raising.

The coal processed is the ¾ in. screenings produced by the Ben Franklin Coal Company and has the following average analysis: Moisture, 2.25 per cent; volatile, 39.40 per cent; fixed carbon, 51.04 per cent ash, 7.31 per cent. B.t.u. per pound, 13,500.

This coal is rescreened over a ½-in. bar screen, and the coarser sizes are crushed to pass a screen of the same size.

The average yield of products derived from one ton of this coal is as follows: Char (12 per cent volatile) 1326 lb.; tar, 30 gal.; gas (800 B.t.u. per cu. ft.), 5000 cu. ft.

The char, after being ground, is passed through a

standard briquetting machine of the Belgian roll type where about 10 per cent of coal tar pitch is used as a binder. The briquets are pillow-shaped and weigh about 2½ ounces.

This type of fuel is ideal for domestic use. It is readily controlled in a heating furnace or stove, will hold the fire for long periods, and retains its shape in the fire until entirely consumed. It will withstand the roughest abuse in handling and shipping, is not affected by weather conditions, and is remarkably free from broken pieces or dust when delivered in the consumer's bin.

As is the case with nearly every machine, the success of its operation is mainly dependent on the method of control and its ability to maintain uniform conditions throughout the entire system.

The heating of the retorts is controlled in accordance with temperature readings taken in the furnace chamber at the feed and discharge end of the retort. All the firing is done at the feed end, where a temperature of 1400 to 1600 deg. fahr. is maintained dependent on the nature of the products desired and the nature of the coal being processed. This produces a furnace temperature of 1100 to 1300 deg. fahr. at the discharge end of the retort. This method of firing has the effect of removing the moisture from the coal and raising it to the distillation temperature before it passes the middle of the retort. All that is then required is to maintain this temperature until complete distillation is effected. The heat required for carbonization is approximately 1200 B.t.u. per pound of coal, or about 60 per cent of the total gas made.

Automatic governors regulate the vapor pressure on the retorts, and uniform temperature conditions are maintained by automatic valves at various points through the gas-handling equipment.

This unit has now been operated over a sufficiently long period of time to demonstrate its ability to produce the required type of products and to prove the reliability of its operation.

The products have been marketed in different localities, and their reception has been such as to leave no doubt as to the prospects for selling large quantities of both the tar products and fuel briquets.

Fig. 2—Battery of Hayes Process retorts, showing feed equipment at the far end

There has been much speculation as to the value of low-temperature tars, and the general impression has been that their only immediate use would be as a fuel and that their value could only be rated as such. Recently, however, there has been shown a remarkable interest in the distillates from low-temperature tars by the manufacturers of synthetic-resin compounds. Due to their high tar-acid content and other peculiar characteristics, these distillates are beginning to find favor in this industry, and their value is indicated by the willingness of several

manufacturers to contract for large amounts at a very good price.

As is the case with every new industrial undertaking, the question arises if it is commercially profitable. The answer to this question is that plans are now under way for the erection of a plant having a coal input of 400 tons per day. The carbonizing units of this plant will be merely a multiplication of the unit now operating, and there will be no untried schemes incorporated in its design. Provision is being made to distill all the tar produced in order to recover a suitable pitch to be used as a binder for the briquets, and only the distillate oils will be marketed.

From the foregoing, it would seem reasonable to conclude that within a comparatively short time the larger producers of bituminous coal will, by the low-temperature carbonization of the coal they produce, place their business, which is now unprofitable, on a profitable basis.

It would also seem probable that the time cannot be far distant when bituminous coal will not be in general use in its raw state as a fuel, but its place will be taken by a smokeless fuel, the product or result of low-temperature carbonization of bituminous coal.

From the present trend in the value of low-temperature tar products, it would appear that by the use of a low-temperature distillation process the coal producer will be able to sell the smokeless fuel resulting from such a process at a price to bring it within the reach of the average domestic consumer.

Fig. 3—Feed end of retorts showing hydraulic main under the operating floor

Labor		
	Cost per day	Cost per ton input
General: 1 superintendent at $12 per day, 1 chemist at $6, 6 general laborers at $4	$42.00	$0.105
Carbonizing plant: 3 foremen at $6 per day; 12 men at $4	66.00	0.165
Steam plant: 3 firemen at $4 per day	12.00	0.030
Briquetting plant: 1 foreman at $6 per day; 2 men at $4	14.00	0.035
Tar distillation: 9 men at $4 per day	36.00	0.090
Total	$170.00	$0.425
Operating Cost per Day		
	Daily cost	Cost per ton input
400 tons slack coal at $1 per ton	$400.00	$1.000
Labor	170.00	0.425
Interest on $600,000 at 7% per annum	116.66	0.290
Depreciation at 10% per annum	166.66	0.411
Royalty at $0.30 per ton	120.00	0.300
Repairs and supplies	75.00	0.187
Power and water	50.00	0.125
Office and laboratory	25.00	0.062
Total cost	$1,123.32	$2.800
Income per Day		
	Daily income	Income per ton input
300 tons briquets at $5	$1,500.00	$3.75
4000 gal. distillate oils at $0.13	520.00	1.30
Total income	$2,020.00	$5.05
Operating costs	1,123.32	2.80
Profit	$ 896.68	$2.25

Estimated Operating Cost and Returns on a 400-Ton Plant

The Processes *of* Combustion *in a* Furnace

By HENRY KREISINGER

Consulting Engineer, Combustion Engineering Corporation, New York

We are always interested in the behavior of molecules. Dr. Kreisinger has made an ingenious and interesting analysis of the molecular activity in the flames and gases of a boiler furnace, where the time elements are fractions of a second. The subject matter is taken from a paper presented before the Engineers' Society of Western Pennsylvania, October 1, 1929.

AT ordinary furnace temperature, the rate of combustion in the combustion space of a furnace, depends entirely on the rate at which free oxygen comes in contact with the combustible in whatever form the latter may exist. If the combustible is in a gaseous state the rate of combustion is equal to the rate at which molecules of oxygen come in contact with the molecules of the combustible. The rate at which such contacts are made is proportional to the product of the concentration of the combustible, times the concentration of the oxygen in a uniform mixture. If C is the concentration of the combustible and O the concentration of oxygen then—

(1) Rate of contacts $= K (C \times O)$

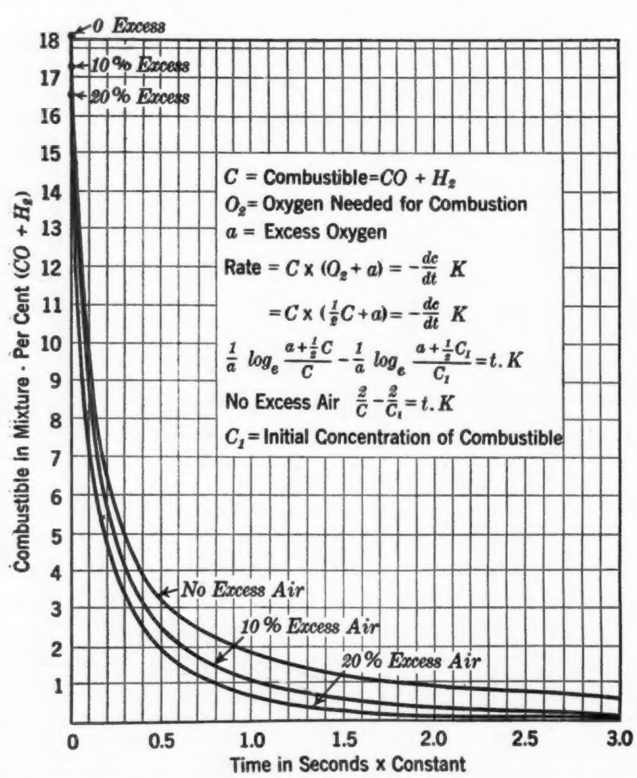


Fig. 1—Probable process of combustion of blast furnace gas

If the combustible burns as fast as it comes in contact with oxygen, each time a contact is made part of the combustible and oxygen in the mixture is used up and the concentration of the two is reduced. With the reduced concentration the rate of contact making is also reduced according to equation (1). This process continues, or should continue, until only a very small quantity of the combustible is left uncombined, and the combustion is nearly completed.

If we take blast furnace gas containing 33 per cent of combustible in the form of CO and H_2 and mix it with air 20 per cent in excess of that required necessary for complete combustion, the concentration of combustible and oxygen, expressed in percentage in the initial mixtures is as follows:

C_1 = combustible = 16.6 per cent

O_1 = oxygen = oxygen required plus 20 per cent

excess $= \frac{C_1}{2} + 0.2\frac{C_1}{2} = \frac{3}{5} C_1$ per cent

The initial rate of contacts $= K \frac{3}{5} C_1^2$

The rate of contact making during any small period of the process of combustion is—

$$C\left(\frac{1}{2}C + \frac{C_1}{10}\right) = C\left(\frac{1}{2}C + a\right)$$

Where $a = \frac{C_1}{10}$ = excess oxygen.

$$(2)\quad C\left(\frac{1}{2}C + a\right) = -\frac{dc}{dt}K$$

On integration equation (2) becomes:

$$(3)\quad \frac{1}{a}\log_e \frac{a+\frac{1}{2}C}{C} - \frac{1}{a}\log_e \frac{a+\frac{1}{2}C_1}{C_1} = t.K$$

With no air excess equation (3) becomes

$$\frac{2}{C} - \frac{2}{C_1} = tK.$$

From equation (3) the concentration of combustible at any time during the process of combustion can be computed. Figure 1 gives three curves of this equation, one for 20 per cent excess air, one for 10 per cent excess air, and one for no excess air. In this figure the ordinates give the percentage of unburned combustible and the abscissas are proportional to the time. The ordinates under the curve give the percentage of combustible at any time during the process of combustion, or, according to the original proposition, the percentage of combustible still left to make contact with oxygen.

The curve shows that the rate of contact making or the rate of combustion is very high during the first part of the process combustion, and then rapidly slows down as the concentration of the active constituent in the mixture is decreased. Comparison of the curve with results actually obtained in burning blast furnace gas indicates that the constant of the abscissa is nearly 1. If the constant is unity, then during the first 0.1 second the percentage of combustible is reduced from 16.6 to 8.3 per cent, or, 8.5 per cent of the combustible made contact and burned, whereas at the end of the first second of combustion the percentage of combustible was reduced only about 0.15 per cent per one tenth of a second. The curve also explains why in a gas engine cylinder the combustion is fairly complete even though the time available for combustion is short.

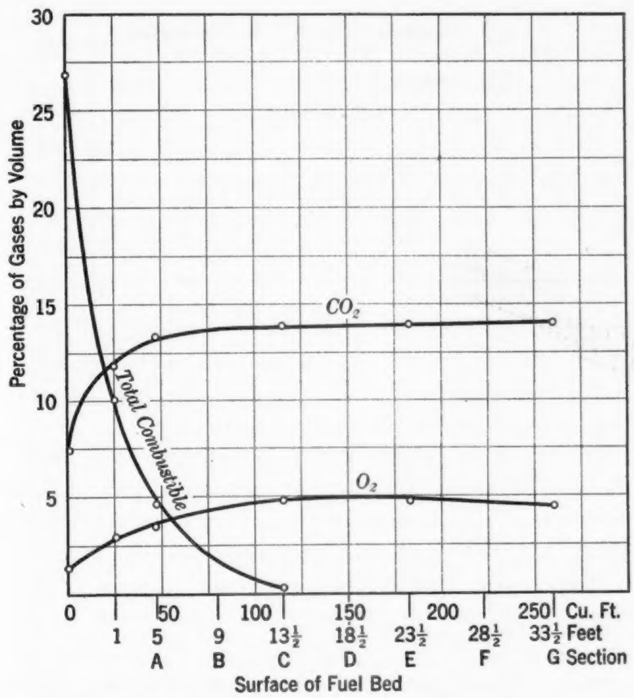


Fig. 2—Process of combustion of gases as shown by the combination of furnace gases at various distances above the fuel bed. (Pittsburgh screenings; rate of combustion 35.6 lb. per sq. ft.)

Very little is gained in completeness of combustion by increasing the time beyond two seconds, which shows that there is a practical limit in the size of the furnace beyond which it does not pay to go.

The curve in Figure 1 holds true for homogeneous mixtures, that is for mixtures in which the percentage of combustible and oxygen is uniform through any section of the gas stream flowing through the furnace. If this percentage is not uniform each part of the section will follow its own curve according to the concentration of the active constituents.

There is very little experimental data available to check up the preceding theoretical discussion although with proper apparatus such data would not be difficult to obtain. Both blast furnace gas and natural gas would lend themselves admirably for such investigations.

Figure 2, which is reproduced from Bulletin 135 of the U. S. Bureau of Mines, gives some experimental results obtained in a coal burning furnace fired with a Murphy stoker. The figure shows the process of combustion of the combustible gases rising from the fuel bed. The curve giving the percentage of total combustible gases is similar in shape to that shown in Figure 1. The drop of the percentage of combustible at the beginning of the combustion process is not quite as rapid as shown by the curve of Figure 1, because the air needed for the combustion was supplied a short distance above the fuel, as shown by the rising percentage of oxygen. If all the air were supplied immediately at the surface of the fuel bed and thoroughly mixed with the combustible gas, the drop of the percentage of combustible would have been much faster and the curve would have been much more like that of Figure 1.

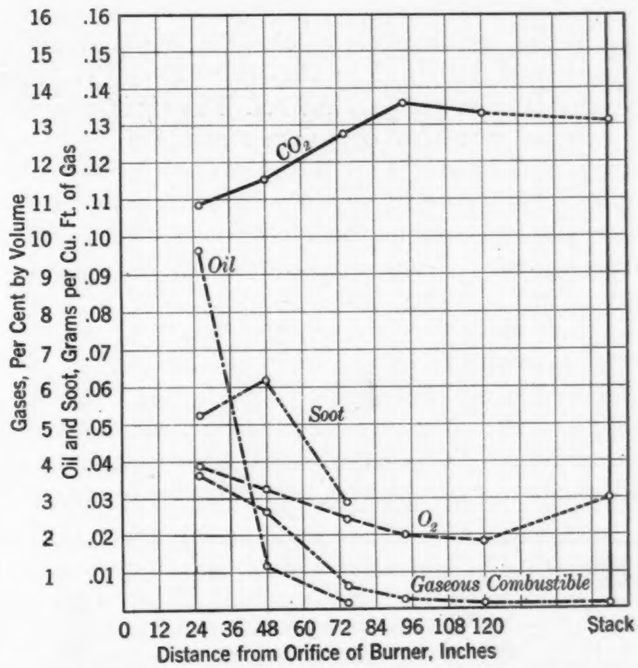
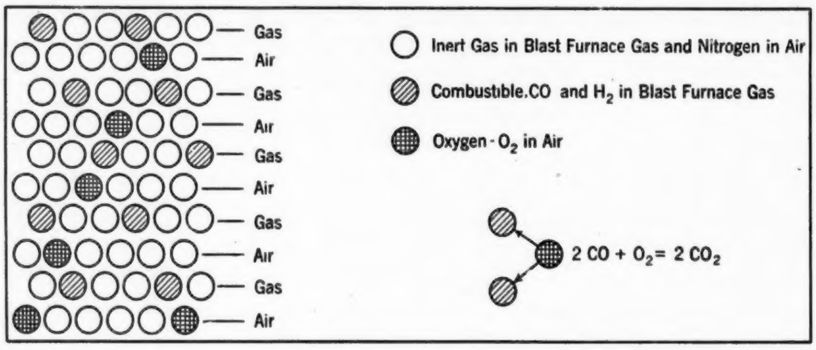


Fig. 3—Composition of gases and weight of oil and soot for tests 16 to 30 on Foster boiler equipped with Coen and Dahl burners

Figure 3 gives some experimental data obtained in an oil burning furnace, of a water tube marine boiler. It is reproduced from Bulletin 214 of the U. S. Bureau of Mines. It shows the composition of gases and weight of oil and soot contained in the furnace gases along the path of the flame travel. The initial process in burning fuel oil consists of partial combustion and partial breaking down of the oil into combustible gases and soot, which in turn burn as they come in contact with the oxygen necessary for their combustion. Apparently the rate of combustion is very high near the burners, the concentration of the combustible and oxygen is rapidly reduced and that of the CO_2 increased. If the concentration of the total combustible were expressed on a common scale it appears that a curve giving such concentration would be similar to that given in Figure 1.

Figure 4 illustrates the probable arrangement of molecules in a homogeneous mixture of blast furnace gas and air 20 per cent in excess of that required for complete combustion. The figure is intended to show why time is required for the active molecules to make contact. Such mixture can be obtained by alternate layers of blast furnace gas and atmospheric air, each layer being one molecule thick. The gas is assumed to consist of one third combustible CO and H_2, and two thirds inert gas CO_2 and N_2. The air is assumed to contain one-fifth of oxygen and four fifths of nitrogen. The excess air is represented by the light circles. The figure shows that only a few molecules of oxygen and combustible are in position to make a direct contact. Most of the other molecules must move some distance before contacts can be made. The inert molecules are in their way and must be either moved out of the way, or the oxygen and combustible molecules must move around them in order to make contacts. The combustible molecules that are near oxygen molecules make contact first and burn. As the process of combustion continues more inert molecules are produced and fewer active molecules are left to make contact and to burn. The contacts occur less frequently and the process of combustion becomes slower.

Fig. 4—Probable arrangement of molecules in a homogeneous mixture of blast furnace gas and air 20 per cent in excess of that required for complete combustion



When blast furnace gas is burned under steam boilers the layers or streams of gas and air are 3 to 4 inches thick and the mixture produced by such layers or streams is far from homogeneous. The layers must travel a considerable distance through the furnace before the mixture becomes nearly homogeneous. As a result, the rate of contact making between the active molecules is lower than shown by Figure 1. Thinner layers and turbulence produce homogeneous mixture quickly. Turbulence in a uniform mixture causes the molecules to change their relative position and thus increases the rate of contact making between the active molecules.

Figure 5 shows the probable arrangement of molecules in a combustible mixture of natural gas and air 20 per cent in excess of that needed for complete combustion and the probable reactions taking place in such a mixture. The mixture is shown to consist of a layer of methane a single molecule thick with layers of air six molecules thick on each side of the layer of methane. The figure is intended to illustrate how far the molecules of oxygen must move before they make contact with the molecules of methane. In a boiler furnace the layers are much thicker and the mixture is less homogeneous than shown in the figure and considerable turbulence is required in and near the burners to make the mixture nearly homogeneous. The rate of contact making and the rate of combustion are probably somewhat like that shown in Figure 1.

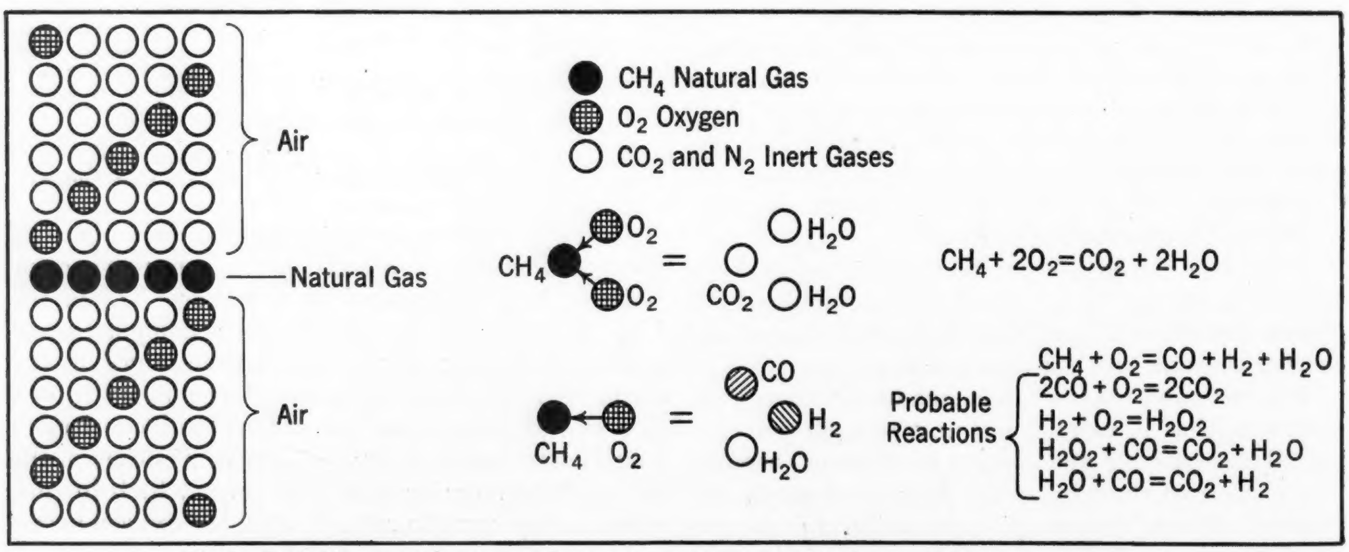


Fig. 5—Probable arrangement of molecules in a mixture of natural gas and 20 per cent excess air

Combined Total Gasification *and* Combustion *of* Coal

The Present Situation and Future Possibilities as Regards Steam Boiler and General Furnace Plant Practice

By DAVID BROWNLIE, London

THE enormous increase in size of the modern super-power station, with a consumption of 1000 to 3000 tons of coal per 24 hours as quite common practice in comparison with only 200 to 300 tons a few years ago, has brought up for immediate consideration the possibilities of combined total gasification and combustion.

Considerable pioneer work has been done in England in combining the gasification of coal with steam generation. This interesting story, as told by Mr. Brownlie, is substantially the early development of what may in the near future become the recognized economical method of utilizing coal as the basis of power generation. The article points out that with low temperature carbonization as a fundamental element of power production, the problem of sulphur gases from chimneys will be reduced to the vanishing point.

In the first place, the striking advances in the efficiency of pulverized fuel firing, and also of mechanical stoking, have rendered the operation of merely total gasification of the coal and consumption of the gas, instead of solid fuel in the boiler furnace, a practice of relatively little importance, at any rate in so far as very large power station plants are concerned. For example, pulverized fuel fired units are operating to-day at 90 per cent continuous steam generation efficiency, quite equal to that of gaseous firing, and it is not much more difficult to dispose of the ash from the boiler setting than with a total gasification generator setting. For very small industrial boiler plants, and particularly where vertical and locomotive type boilers are used, simple total gasification has the advantages as against hand firing of more efficient combustion as well as the complete absence of smoke.

The most important aspects of total gasification, not only for steam boilers but for any furnace setting of large size, relate to the possibilities of including low tenperature carbonization, with the recovery of the valuable tar and light oils, and also the complete elimination of sulphur gases from the boiler plant. There is certainly much material for thought as regards any plant burning 500 or more tons of coal per 24 hours in connection with the possibilities of combining low temperature carbonization and total, or partial gasification, in one setting, adjoining the boiler plant.

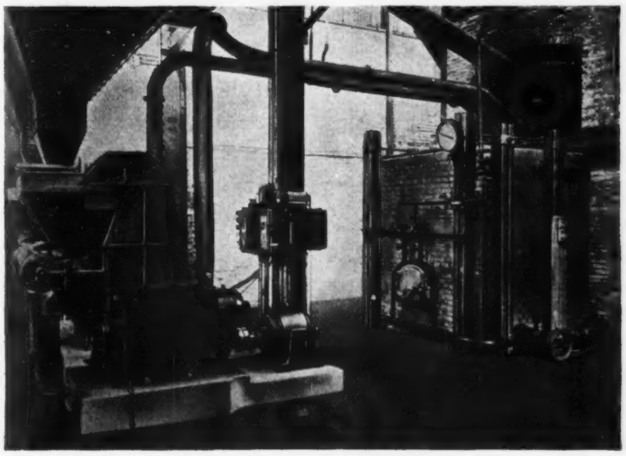


Fig. 1—Typical gasifuel plant applied to a metallurgical furnace

The whole of the gases and vapors would thus be passed through a cooling, condensing, and scrubbing plant for the recovery of the low temperature tar and light oils, followed by a purification operation to eliminate sulphur—mostly in the form of the simple H_2S. The low temperature process is quite different in this respect from high temperature carbonization in coke ovens or gas plants, where decomposition occurs with cracking of the tar, and the formation of all kinds of complicated sulphur products which are not easy to separate. The purified gas would then be available for burning in the boiler setting, without any ash and clinker having to be handled, and also with complete elimination of the troubles which occur when sulphurous and sulphuric acid gases are discharged from the chimney.

The principle of total gasification and combustion can of course be applied according to a considerable number of general methods, the chief of which are as follows:

1. Simple total gasification in an ordinary producer gas generator, not integral with the boiler plant, having the gas merely piped to and burnt in, the boiler plant, with no by-products of any value and without elimination of sulphur.
2. Simple total gasification in a producer gas generator forming an integral part of the boiler plant setting, without recovery of the by-products or elimination of sulphur.
3. Combined low temperature carbonization and partial gasification in a vertical,

continuous, producer gas retort unit adjoining the boiler plant, with recovery of tar and light oils, elimination of sulphur, and with combustion of the gas in the adjoining boiler plant setting. The solid fuel resulting could be sold separately or burnt in the boiler plant either by mechanical stokers or pulverized fuel firing, along with the gas.

4. Combined low temperature carbonization and total gasification in a vertical continuous, producer gas retort adjoining the boiler plant, with recovery of tar, elimination of sulphur, and combustion of the gas in adjoining boiler plant setting.

The present situation and the future possibilities of these four different general methods can now be considered as follows:—

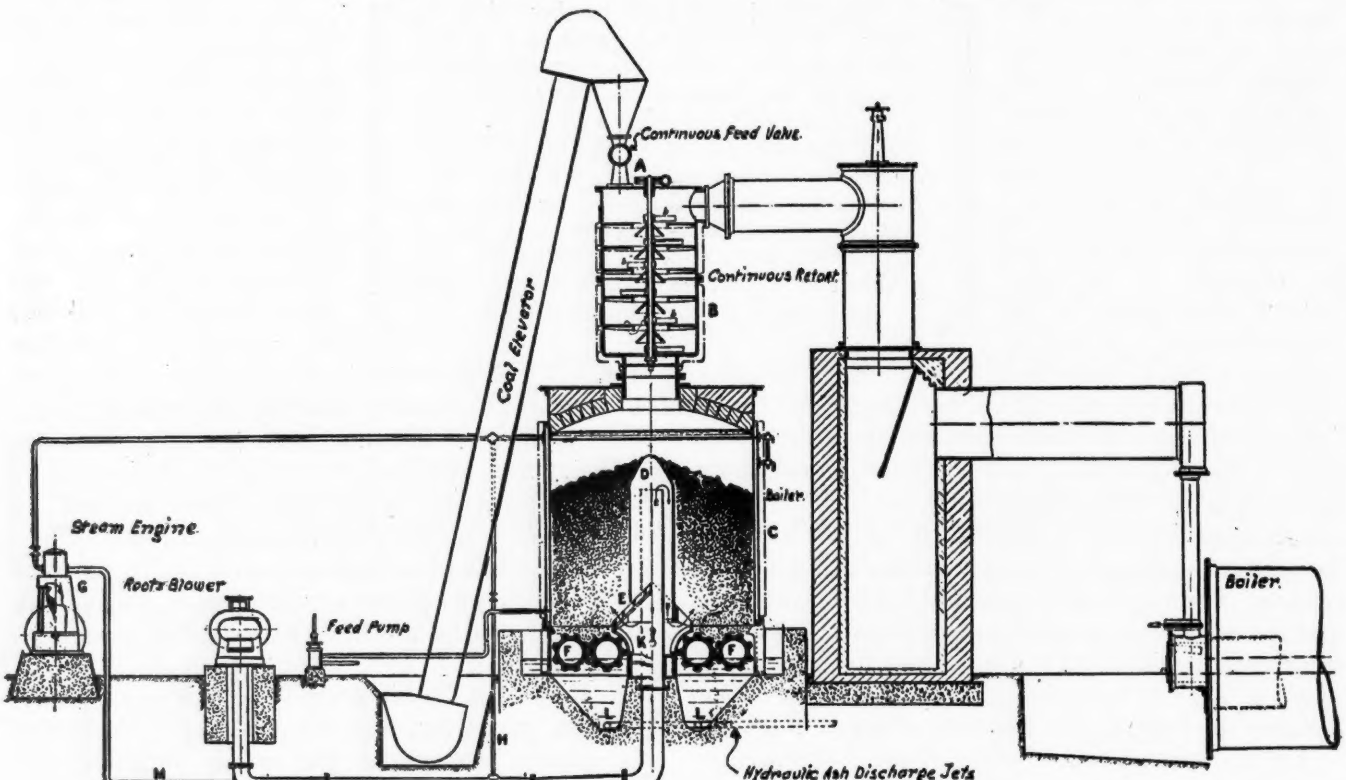


Fig. 2—Wollaston combined preheating and total gasification plant for bituminous coal, with the gas used as fuel in a Lancashire boiler not arranged integrally

In the first place, simple total gasification in an adjoining producer gas generator offers no advantages to-day, as already indicated, because of the high efficiency of pulverized fuel and mechanical stoker firing, although there were quite pronounced claims for such a method 25 years ago, when the average thermal efficiency with solid fuel fired boiler plants did not exceed 60 to 65 per cent for continuous average operation.

Second, the general method of total gasification in a producer gas generator integral with the boiler setting is now being developed to a considerable extent in Great Britain, especially as represented by the "Wollaston" method and the 'Gasifuel" method, while some attention has been given to the matter in Germany, especially by Dr. Albert Wirth of Aix-la-Chapelle. Both the Wollaston and the Gasifuel processes will later be described, but in advance it may be stated that they are intended more specifically for the industrial boiler plant, that is for vertical, locomotive, Lancashire, and Scotch marine boilers, with the claim that a system of this kind in actual practice gives more efficient results than the usual inefficient hand firing with solid fuels. Here again, it is difficult to visualize the exact advantages for the general principle of combined total gasification and combustion, using a generator integral with the boiler plant setting, in connection with large water-tube boilers in which, as previously mentioned, a thermal efficiency up to 90 per cent is now being obtained for continuous operation with pulverized fuel firing, and 94 per cent, almost the theoretically possible figure, has been reported for short tests.

It may be remembered also that Chapman has recently given some considerable attention to this subject in the United States, and undoubtedly, for a very large fuel consumption, the ordinary type of producer gas generator, even with completely mechanical operation, (that is coal feed, agitator in the fuel bed, and ash and clinker plough discharge), is not suitable for water tube boiler plant operation. The requirements for success are a much more modified design embodying a high-speed, completely mechanically operated generator built in the bottom

of the water-tube boiler setting so as to operate with a fuel bed of much greater size, that is 10 to 12 feet diameter, certainly on the basis of present knowledge the total net advantage of such methods is problematical, as regards increased thermal efficiency, recovery of low temperature tar, and the elimination of sulphur.

The third and fourth methods combining low temperature carbonization and either total or partial gasification, have not yet been operated anywhere for boiler plant or other large furnace practice. As regards total gasification there are 20 or 30 different processes available in the world which will yield from 150,000 to 180,000 cubic feet of gas of about 150 to 180 B.t.u. per cubic foot per ton of raw coal. In addition, the usual amount of 15 to 20 gallons of low temperature tar would be recovered in the condensers. It will probably be safer, however, to assume that no light oil will be recovered because of the large volume of gas, in spite of the great advances in the use of activated carbon.

Similarly with combined low temperature carbonization and partial gasification, there are over 20 processes to choose from, the average yield per ton of coal processed by methods of this description being 25,000 to 55,000 cubic feet of gas of 220 to 250 B.t.u. per cubic foot, 15 to 20 gallons of low temperature tar, probably 1 to 2 gallons of light oil, (which is partially recoverable) and from about 38 to 55 per cent of solid low temperature fuel containing less than 10 per cent volatile matter. This low temperature fuel can, of course, be burnt in the boiler plant if necessary, and naturally the degree of partial gasification can be altered as required merely by adjusting the air and steam blast at the bottom of the setting so as to give more or less residual solid fuel according to circumstances. In both cases the gas is easily purified from sulphur, and the general interest in the process will therefore be obvious because of entirely clean and non-deleterious chimney tops with no smoke, dust or other solid particles, and no sulphurous or sulphuric acid.

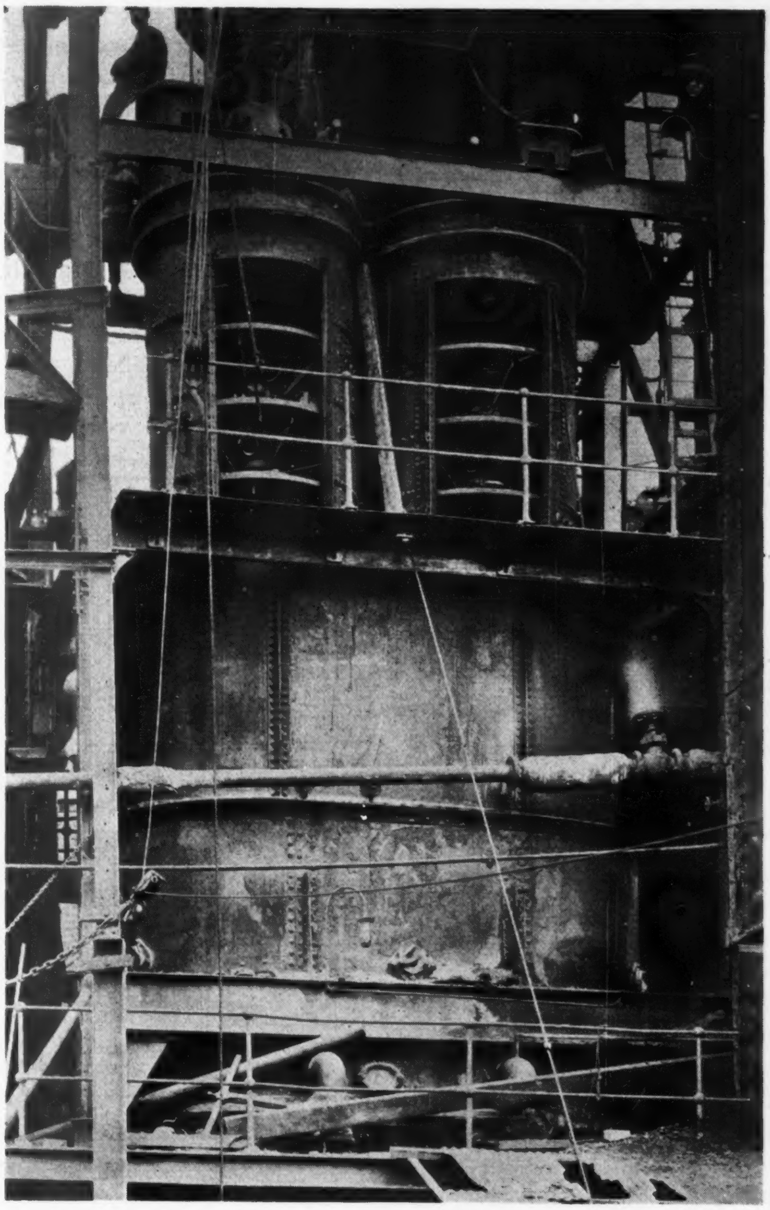


Fig. 3—A non-integral Wollaston combined preheating and total gasification installation, showing arrangement for two preheaters or precarbonization units

The Wollaston process of simple total gasification integral with the boiler plant setting, is the invention of T. Roland Wollaston of Manchester, controlled by Wollaston Gas Producers (Manchester), Ltd. Work on this process was commenced in 1914. It should be mentioned, however, that Wollaston has two processes, the second of which combines preheating and total gasification in a producer gas setting not integral with the boiler plant, and is intended primarily to permit the use of difficult coking bituminous coals in the manufacture of producer gas.

Most of the Wollaston boiler plants, and there are now a considerable number operating in England, are operating in connection with the Cochran vertical boiler. The general principles, indicated in Fig. 5, show the total gasification generator at the bottom of the Cochran boiler setting forming one combined unit. In this case "A" is the generator filled with coke breeze or other material. A throat "F" leads up to the combustion chamber, into which the solid fuel is thrown so as to give a certain degree of pre-drying. At the bottom is a grate "B" with a water seal "C", and the air blast, secured by means of a small fan in the circuit, enters at the point "K". The primary air for gasification, controlled by a

damper "M", then passes underneath the generator, while the necessary amount of exhaust steam or water spray is admitted at "O". All the gas formed then passes up by way of the vertical channels "G" and is burnt in the combustion chamber "E", while from the main pipe "K", as controlled by a damper "N", the secondary air is passed round the jacket of the generator and up by channels "H" so as to burn the gas, the same small fan therefore supplying both the air for gasification, and for the combustion of the resulting gas. The results in general are excellent,

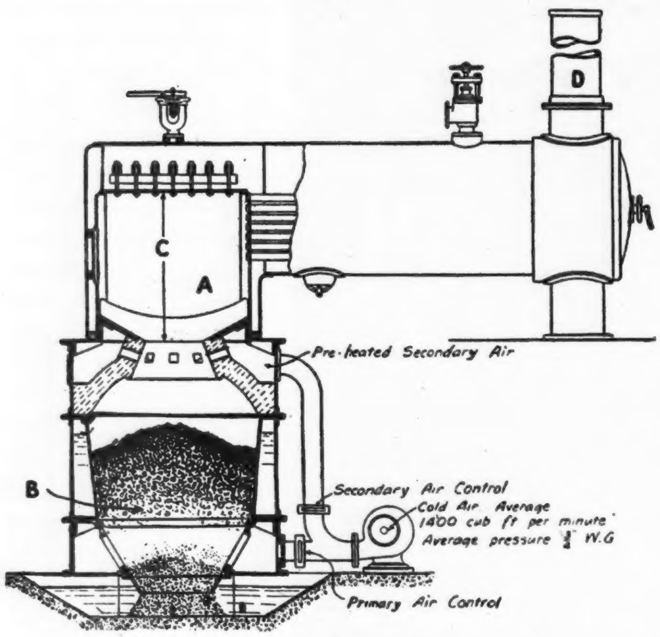


Fig. 4—Combination of locomotive boiler with Wollaston total gasification generators in integral setting

and the Cochran vertical boiler can easily be run in practice at 75 to 82 per cent continuous thermal efficiency, whereas a boiler of this type with hand firing does not, as a rule, exceed about 55 per cent. There is the great additional advantage of complete absence of smoke.

In Fig. 4 is shown the application to the locomotive type of boiler, the principle being exactly the same, while for Lancashire, Scotch, or other internally fired horizontal cylindrical boilers the generator must be built in front of the setting, and is therefore not quite so suitable.

In the second Wollaston process for the manufacture of producer gas, the pre-heater or retort is fixed upon the top of the generator, and is divided transversely into a series of compartments with agitators so arranged that the descending raw coal is subjected to a certain degree of carbonization by the total volume of the hot producer gas passing up through it from the generator below. The gas can be readily burnt in any adjoining boiler plant, particularly if equipped with Lancashire or water-tube boilers. One or two plants using this principle are running in England, but there has not yet been adopted the method of treating the gas on the way to the boiler for recovery of the tar and the elimination of sulphur.

The Gasifuel process is controlled by Gasified Pulverized Fuel (G.P.F.) Ltd., of London, and is primarily the work of Ernest S. Suffern, an American engineer who was for some time resident in London.

The basic principle of the Gasifuel process is to use pulverized coal as obtained from an adjoining unit pulverizer, but instead of burning the pulverized fuel direct, to secure first a partial or complete gasification on "turbulent" principles and then to burn the gas with a short flame burner also on the turbulent principle. In the latest design of this system, as applied to a Lancashire boiler, the pre-gasifying chamber is of fire brick, and is located so as to project just inside the furnace tube. There are two such pre-gasifying chambers and burners set side by side for each boiler, that is, one for each of the two furnace tubes.

The first experimental unit embodying these principles was started up in March 1926 at the works of

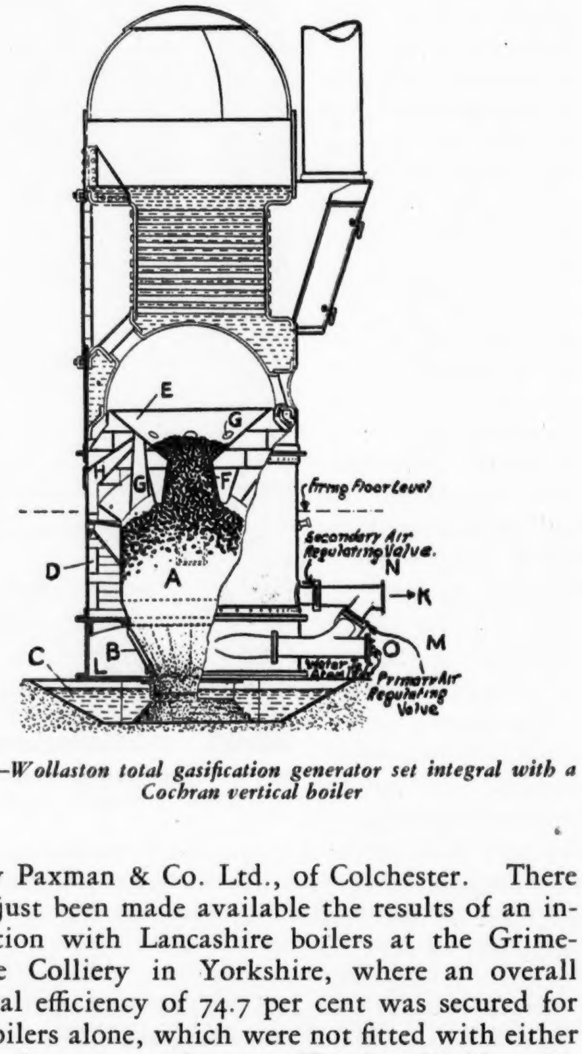


Fig. 5—Wollaston total gasification generator set integral with a Cochran vertical boiler

Davey Paxman & Co. Ltd., of Colchester. There have just been made available the results of an installation with Lancashire boilers at the Grimethorpe Colliery in Yorkshire, where an overall thermal efficiency of 74.7 per cent was secured for the boilers alone, which were not fitted with either economizers or superheaters. This is a highly satisfactory figure, since at least 80 to 85 per cent would be secured by the installation of apparatus for recovering the waste heat by way of the feed-water and the steam; that is, in economizers and super-

heaters, the heat in the waste gases being equivalent to 17.5 per cent of the total heat of the coal.

It is familiar knowledge that many attempts have been made in the past to gasify pulverized coal for the manufacture of producer gas. This principle of almost simultaneous combined gasification and combustion represents another possibility for the utilization of coal or other solid fuel in pulverized form and has possibilities for many different types of applications quite apart from steam generation.

Ford to Install Largest Capacity High Pressure Boilers in the World

THE Ford Motor Company, Detroit, Michigan, recently closed a contract for two steam generating units to operate at 1400 lb. steam pressure and 750 deg. fahr. superheat, for installation in the Fordson power house. These units will each have a maximum capacity of 700,000 lb. of steam per hour, the largest steaming capacity of any boiler units ever built for pressures as high as 1400 lb. per sq. in.

In 1919 the Ford organization built the first large industrial plant incorporating pulverized coal as its primary fuel. In 1926 four units at the Fordson plant were redesigned and rebuilt so that their capacity was doubled, still retaining the same efficiency. This was made possible primarily by the substitution of water-cooled walls for the fire brick wall originally installed, and by the installation of air preheaters. The success of both the initial installation and the rebuilt units reflect the good judgment and foresight of Ford engineers in pioneering the adoption of relatively new methods and equipment which were not yet recognized as standard practice.

Today, the Ford organization again asserts its leadership in the industrial power plant field by contracting for two high pressure steam generating units which are designed for a maximum guaranteed capacity of 700,000 lb. of steam per hour per unit. This guaranteed capacity, according to the engineers responsible for the design of the new installation, does not represent the absolute limit as the contract guarantees are believed to be quite conservative.

The equipment comprising each unit includes a boiler, a water-cooled furnace, two air preheaters, an economizer and a pulverized fuel firing system.

The boiler is double-set and of the bent-tube, multi-drum type. It includes one 40 inch diameter forged steel steam drum of three inch shell thickness, and two top and two bottom forged steel drums, each of 40 inch diameter, and 5¼ inch shell thickness. The total weight of each boiler alone will be 1,120,000 lb. The air preheaters are of the plate type, each preheater consisting of 180 elements, 18 ft. high and 5 ft. wide. The heating surface of each preheater will be 32,400 sq. ft., or 64,800 sq. ft. per boiler. The furnace is of the all-metal water-cooled type and is composed of fin tubes, with the exception of the bottom water screen, which consists of plain tubes. The economizer is of the return-bend U-tube type with extended surface in the form of fins. The total economizer surface will be 5,786 sq. ft., thus making the total heat absorbing surface of each unit 108,296 sq. ft., of which less than 30 per cent is boiler heating surface proper.

The boiler will be fired by pulverized fuel blown into the furnace through twelve horizontal burners located in the furnace corners. These burners are aimed tangentially to an imaginary circle in the center of the furnace so that, when in operation, they will effect a swirling, turbulent mixing of the combustible constituents of the fuel with the combustion air. The coal is to be pulverized in large roller mills from which it will be transported to storage bins located adjacent to the boilers.

The adoption of high steam pressures by the Ford organization has two principal aspects; one is that high pressures are rapidly becoming established practice in industrial power production, where high efficiencies and economy are imperative; the other is that the dividing line between central power station practice and industrial power station practice is gradually disappearing. Today there are many industrial power plants which can successfully rival the largest central station plants in steam production, overall efficiency and economy of operation; they present practically the same problems in design and construction and require the same highly specialized operating personnel.

The adoption of high pressures by Ford—a recognized industrial leader—makes the outlook for improved steam plant economy a very encouraging one.

Recent Developments *in* Stoker Design

By H. D. SAVAGE

President, Stoker Manufacturers' Association, New York

It may prove surprising to many readers to learn that improvements in stoker design have retained for stokers their fair share of the fuel burning business despite the wide adoption of pulverized fuel firing. There has been comparatively little printed information on this subject, and this paper is, therefore, of particular value as an authoritative summary of the stoker situation to date. The co-authors who collaborated with Mr. Savage in the preparation of this paper were, R. A. Foresman of Westinghouse Electric and Manufacturing Co., J. G. Worker of American Engineering Co., J. W. Armour of Riley Stoker Corp., H. H. Hyde of Flynn and Emrich Co., R. L. Beers of Detroit Stoker Co., and R. C. Denny of Combustion Engineering Corp.

AN advance in stoker design by any one manufacturer may have a limited appeal, but the composite advance by the several leading manufacturers of stokers must increase this appeal to all of those who are in any way interested in stokers. The composite story becomes a cross section of the present status of the stoker combustion art.

Each manufacturer of stokers has made improvements according to his conception of the art of stoker firing and the requirements of the market. Research and test work has been undertaken in diligent effort to improve not only the design of stokers themselves, but also the conditions under which they will render the most satisfactory service. In addition to this work on stokers themselves, the problems of furnace design have been the subject of an immense amount of study by stoker engineers.

GENERAL DEVELOPMENT

The development of stokers has taken place along two radically different lines, in each case synchronizing with a positive commercial demand. Stokers adaptable to large steam generating units have developed principally along the line of size, those for small boilers principally along the line of convenience.

All are aware of the well-defined trend toward steam generating units of larger and larger size. It has been found economical to build steam turbine generators in sizes of 150,000 kw. and 200,000 kw. The same factors of economy are responsible for a demand for steam generating units, ranging in their larger sizes from 500,000 to 1,000,000 lb. of steam per hr.

Pulverized fuel firing has proved somewhat more popular for the bulk of these very large modern steam generating units. It has been comparatively easy to expand the combustion principles, and multiply the mechanical apparatus of pulverized fuel systems. Mechanical stokers have also been increasing rapidly in size, and it is quite certain that during their recent growth no obstacle so far encountered has indicated any specific limitation, either mechanical or economical.

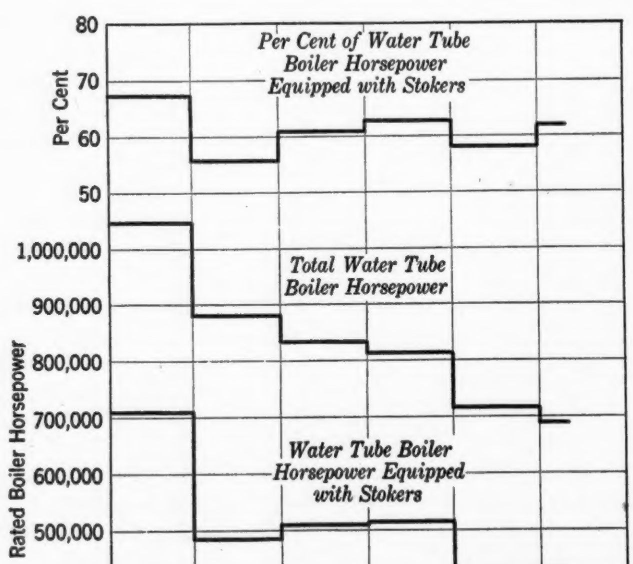


Fig. 1—Chart showing ratio of stoker business to available market. Figures are from reports by the United States Department of Commerce.

This growth in the size of stokers is perhaps more remarkable when the mechanical difficulties that confront the designer are fully comprehended. In either the multiple retort or the chain grate stoker, a material increase in size may render its former structural formation entirely impractical. The larger stokers may require almost 100 per cent new design in order to secure the necessary strength of structure, resistance to heat, and the feeding and distributing of the fuel and air.

An interesting feature of this development work

in large stokers is the fact that both stoker manufacturer and customer join in the responsibilities that are involved. Models are out of the question, and a newly designed larger stoker must make good as a practical operating machine, and must meet its predicted performance tests in the customer's plant, without the benefit of preliminary trial installation.

The fact that such stokers practically always equal or better the expectations of their sponsors is a splendid tribute to the accurate knowledge of the art of combustion shared in general by both stoker and power plant engineers. There is, furthermore, a certain elasticity in the underlying principles of stoker firing which accounts for the success attained by various stoker manufacturers in working out their particular development programs along lines which are not always parallel, but along which each manufacturer attains a definite measure of success.

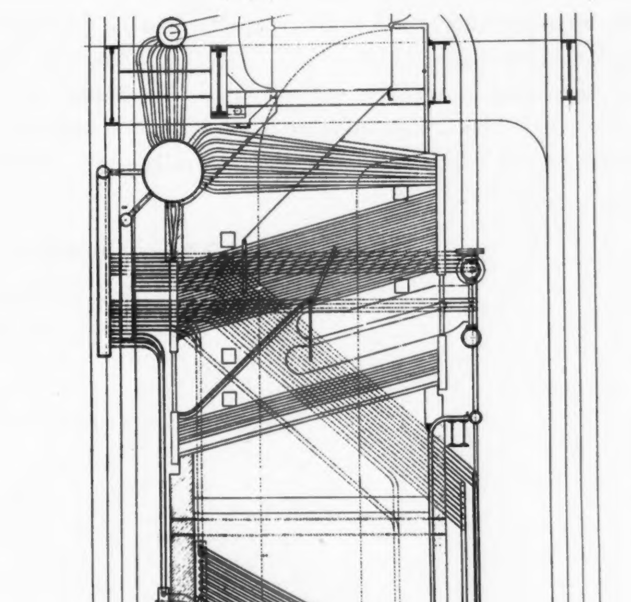


Fig. 2—Typical large single end multiple retort stoker and boiler setting. Total projected grate area per unit is 713 square feet

DEVELOPMENT OF SIZE

From a production of, say, 100,000 lb. of steam per hr., stoker installations have gradually increased in size till today the production of 400,000 lb. per hr. is both feasible and economical. For one installation 500,000 lb. of steam per hr. is expected. The projected areas of stokers required for such steam production are of the order of 700 sq. ft., and a number have been or are being built of approximately this size.

In the multiple retort type, single end stokers ranging up to 713 sq. ft. of projected area and double end stokers up to 716 sq. ft. have been or are being built. A steam production of the order of 400,000 to 500,000 lb. is contemplated from these installations.

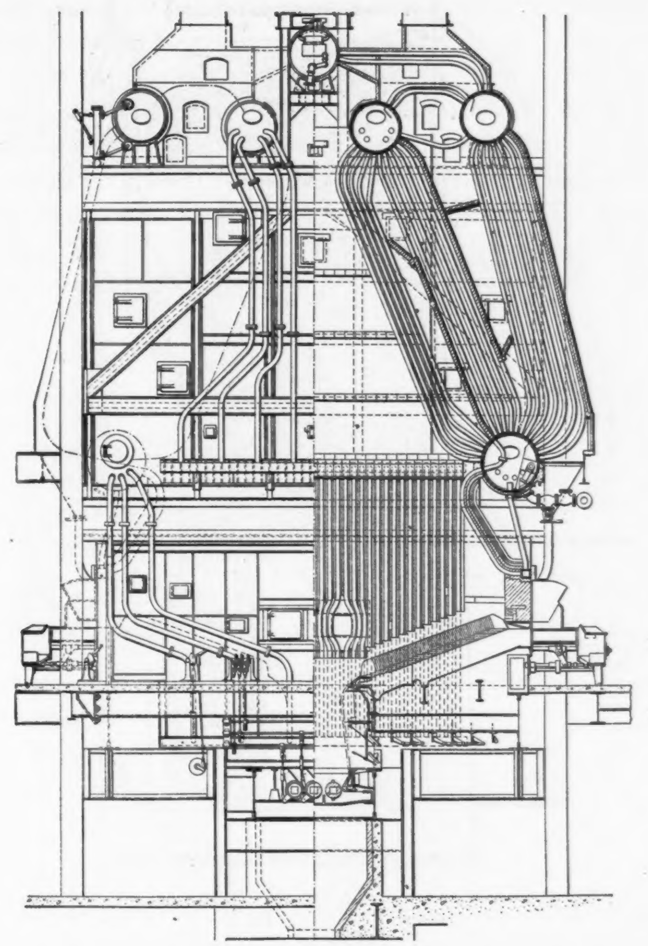


Fig. 3—Typical large double end multiple retort stoker and boiler setting, with 716 square feet of total projected grate area per unit

The chain grate type of stoker has developed from the 420 sq. ft. of grate surface furnished at Crawford Avenue some years ago by several manufacturers, to 528 sq. ft. in one installation and 684 sq. ft. in another, both in the United States, with 700 sq. ft. the maximum in England. The contemplated steam production with these stokers is appreciably lower than with the multiple retort underfeeds, due chiefly to the application of the chain grate stokers to the burning of low grade fuels.

Considerably larger stokers can be built, and

modern high combustion rates can be consistently maintained upon them. The principles of construction now used in the larger stokers are directly applicable to the structure required for much larger sizes. High average combustion rates are a product of operating skill and refinement in stoker and furnace details; the problem here with respect to still

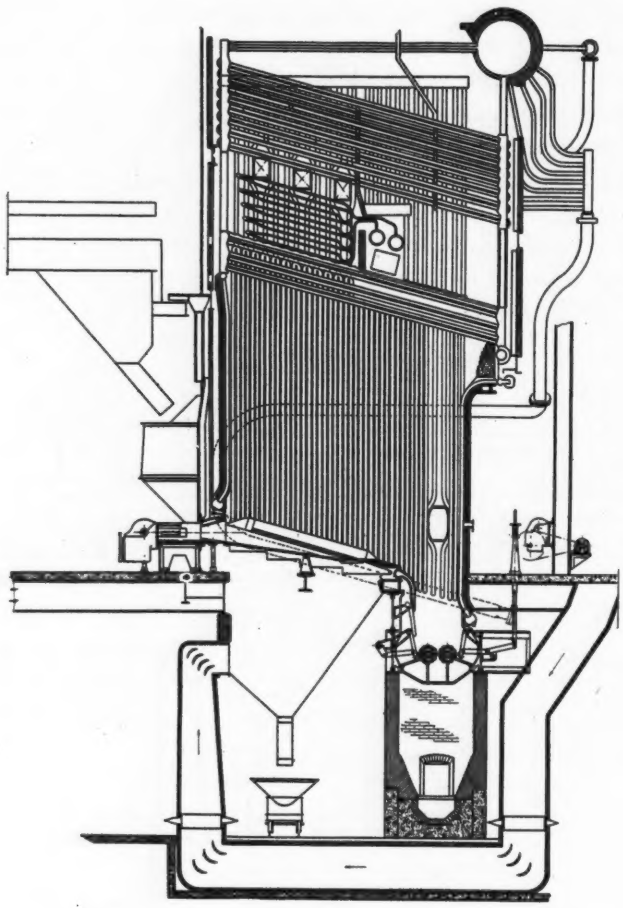


Fig. 4—Multiple retort stoker of 479 square feet total projected grate area

larger stokers is but the carrying on of the best practice now in effect.

COMBUSTION RATES

It is difficult to make any compilation that will evidence an increase in combustion rates. It may be perfectly true and somewhat obvious that combustion rates have been and are gradually increasing. Various comparatively old records of 70 to 75 lb. of coal per sq. ft. of stoker area per hr. would seem to rob any recent achievements in this line of all claim to recent development. The more prosaic figures of maximum operation under ordinary plant operating conditions would be much more important, but they are somewhat too elusive for accurate compiling.

There is, however, improvement to report along this line which will have recognized, if not quantitative, value. The problem of increasing combustion rates for regular operation involves pretty much all of the related functions of a stoker. Particularly must the feeding and distributing of the fuel be worked out so as to handle correctly the larger quantity of fuel per square foot, and to secure its economical combustion. Air distribution, speed of stoker mechanism, and fire thickness are factors of this problem which do not offer much difficulty. Ash elimination is a serious problem only in the case of coals having a low fusion ash, or extraordinary clinkering tendency. Furnace design is of extreme importance, and its problem with respect to high combustion rates has been solved successfully by the work of stoker engineers in combination with the manufacturers of water cooled walls and air cooled refractory walls. This subject, however, is not regarded as within the scope of this paper.

Various stoker manufacturers have attacked the problem of development individually, as they

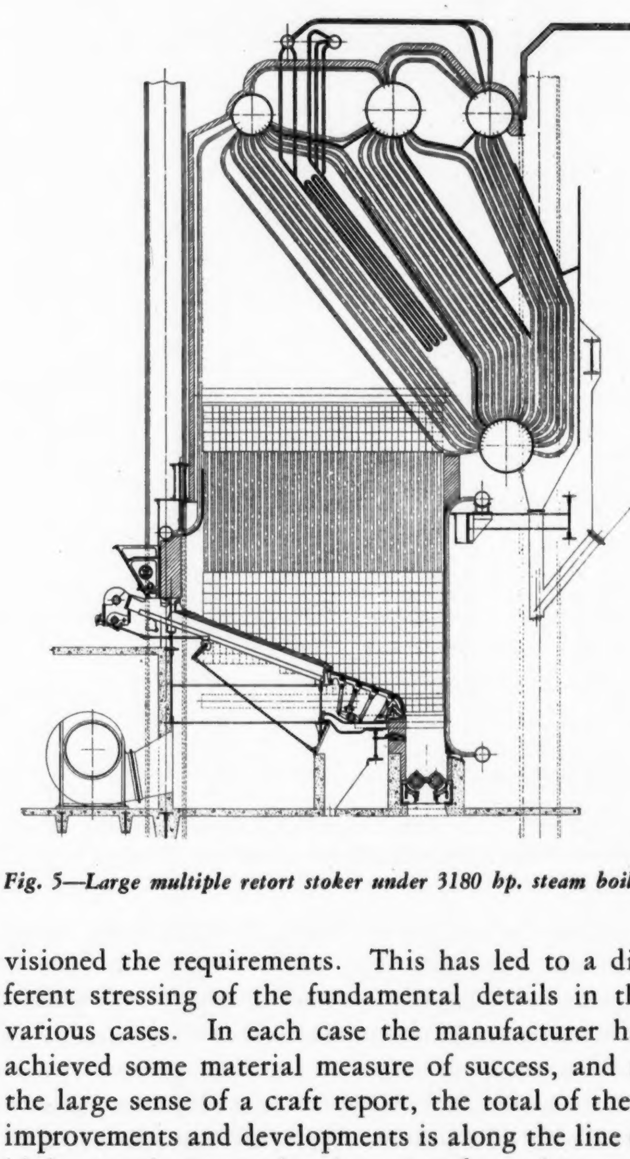


Fig. 5—Large multiple retort stoker under 3180 bp. steam boiler

visioned the requirements. This has led to a different stressing of the fundamental details in the various cases. In each case the manufacturer has achieved some material measure of success, and in the large sense of a craft report, the total of these improvements and developments is along the line of higher consistent combustion rates for stokers.

In multiple retort underfeed stokers, one manufacturer has developed particularly the length of retort, together with special control of secondary rams; the object being to secure high combustion rates for his large size stokers. Another manufacturer has developed a deep ram and deep retort, and also special functioning of secondary rams; the

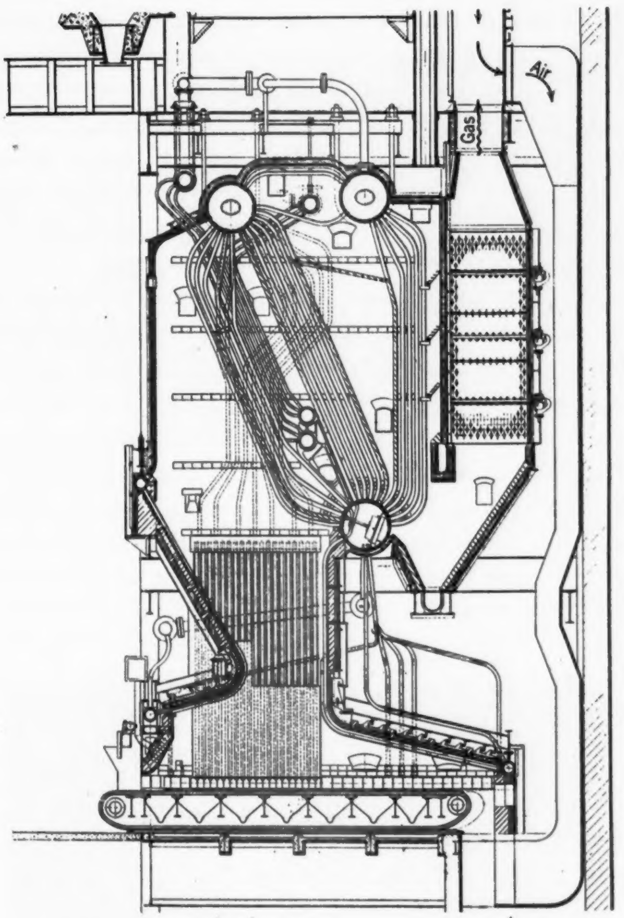


Fig. 6—Typical large chain grate stoker, with a grate area of 528 square feet

object being practically the same, although the method is different. Still a third manufacturer has centered his development particularly on the overfeed section of this type of stoker, enlarging and articulating it according to his view of the requirements of proper combustion, and this also is a still different method of attacking the common problem. In these three developments the object is to provide for practical handling of the fuel as a fire, over greater distances from the point of feeding than formerly. The problem has been difficult and very serious, but by no means insurmountable, and in each case a certain measure of success has resulted.

For the chain grate type of stoker, higher combustion rates have been largely the result of improved furnace design. The various modifications of the rear arch have lifted the old 45 lb. per sq. ft. rate up to the present 60 lb. rate. Of course, there are instances of higher rates. Special high rates are not to be emphasized, but the gradually increased rate of coal burning in every day practice should be.

Along with improved furnace design, there has been an increase in speed of grate travel. For bituminous coals the grate speed has increased from an old limit of about 30 ft. per hr. to a present day usage of about 60 ft. per hr. For anthracite coal the older limit of about 45 ft. has been superseded by present maximum speeds of about 100 ft. per hr.

The development in higher combustion rates has always been gradual. For all the various fuels, and with all the various stokers, there has usually been a pioneer installation that demonstrated some principal point of improvement. This point has then been tried out and varied in other subsequent installations, with the result that its advantages have

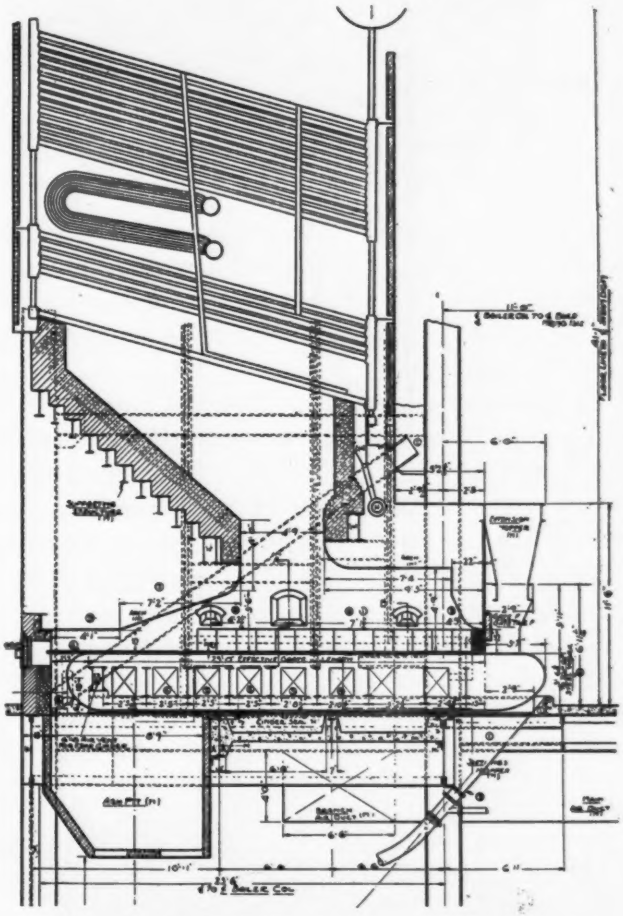


Fig. 7—Chain grate stoker of 483 square feet grate area

been gradually but thoroughly worked into the whole practice of the art. In time the discoveries and improvements, whether originating in operating skill or vision of stoker owners, or finding their inception within the organization of any particular manufacturer, are absorbed and distributed widely throughout the whole field of combustion of fuel on

stokers. This, while far from specific, and incapable of mathematical precision of expression, does constitute a real and practical advance in the art.

PREHEATED AIR

Preheated air has caused all stoker manufacturers to build stoker bodies, and all parts in contact with the preheated air, so as adequately to provide for

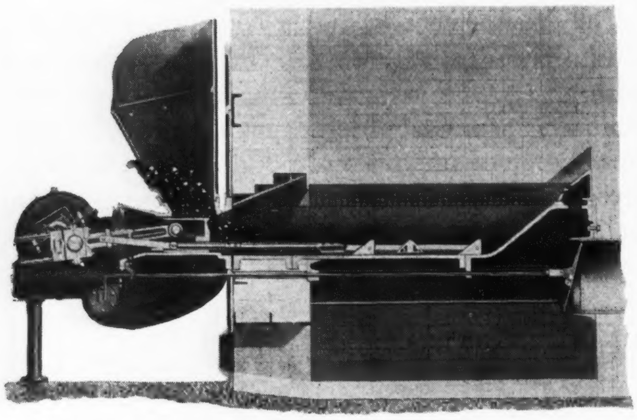


Fig. 8—Single retort stoker with auxiliary ram

structural expansion. There is a trend toward making the air openings through the various kinds of grate surface in the different types of stokers generally larger for preheated air than for air at normal room temperature.

The allowable limit of preheated temperature of air to stoker fires depends partly on the characteristics of the fuel. Certain coals with preheated air have a tendency to fuse or mat over, thus becoming almost impervious to commercial forced draft air pressures. In certain cases, 300 deg. fahr. has been found to be a limit on this score.

A temperature of 350 deg. fahr. for preheated air with stokers seems to be regarded as safe both by stoker manufacturers and the public which they serve. There is a divided opinion as to the practical effect on stokers of air at higher temperatures. The burden of objection to higher temperatures is on the score of excessive maintenance of grate surface elements.

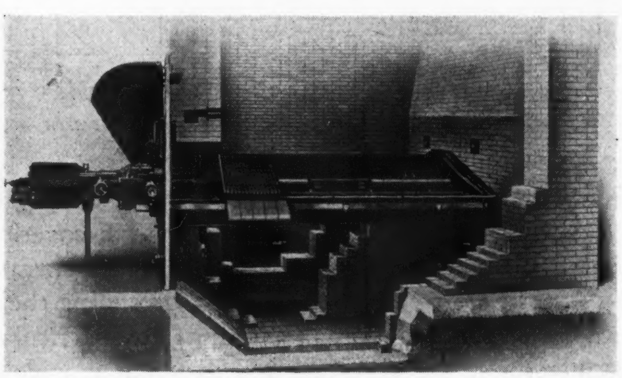


Fig. 9—Single retort stoker with link motion of grate bars

SMALL STOKERS

The single retort stokers, usually considered for boilers of from 200 to 600 hp. in size, have, as a class, developed recently only with respect to convenience in the arrangements for feeding coal and supplying air. The interiors of these stokers have undergone practically no change. But a rather definite demand for electric drive and self-contained source of air supply has caused the development of compact combinations of geared drive and fan, worked out for simultaneous driving from a single motor.

In still smaller sizes a large market has recently opened up for stokers to fit under small heating boilers. Practically all of these machines use the combination of speed reduction gear for coal feeding, together with a small fan for forced draft air, both driven from a common motor. In fact, the development of this style of combined fuel feeding and source of forced draft air in these very small stokers has set the style for this arrangement with the small stokers for power boilers.

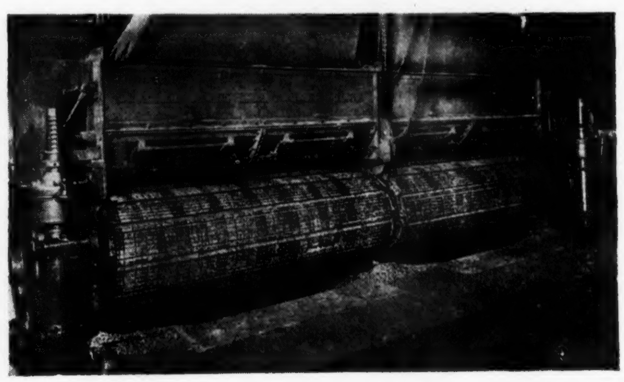


Fig. 10—700 square foot chain grate stoker. There is no dividing wall in the furnace between the separately driven chains

The stokers for heating boilers are almost all of the screw feed type, where the coal is fed from the bottom of a hopper, through a delivery pipe, into the bottom of a retort, by means of a slowly revolving screw. Single retort stokers for small power boilers are usually larger in size, and utilize rams for feeding the fuel from hopper to retort.

As a class, the heating boiler stokers do not provide any agitation of the fire, whereas the small power boiler stokers have means for agitation in order to break down the coke masses, and in this point they resemble the action of the large multiple retort stokers.

THE FIELD FOR STOKERS

A study of the statistics compiled by the Department of Commerce has yielded information that indicates the continued popularity of the stoker as a means for burning fuel under steam power boilers. These statistics include a summary of the horsepower of water tube boilers sold each year in the United States, and reported separately from the horsepower of fire tube boilers. It may be assumed without serious error that the horsepower of water tube boilers represents the potential market for all methods of firing steam power boilers. This set of figures dates from 1919.

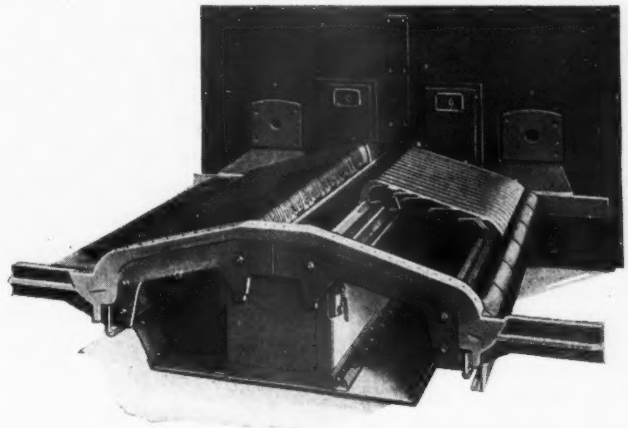


Fig. 11—Single retort stoker with alternate moving grate bars

There are also further figures for the number of stokers purchased each year, and these are divided into totals for fire tube and for water tube boilers. In addition, the horsepower of boilers fitted with stokers is given. These figures date from 1923, and while not entirely inclusive will serve with sufficient exactness to indicate the trend of stokering in the power boiler field.

The horsepower of water tube boilers that are stokered compared to the total horsepower of water tube boilers sold yields a percentage figure which, commencing with 1923, does not vary to any great amount from 60 per cent. There is no observable tendency in this curve to drop off, and it may be concluded that stokers are holding their own in the available market of power boilers.

It may also be added that the best information that can be secured, which, however, is not accurate enough to show as a curve, indicates something like 20 per cent of the horsepower of all water tube boilers are being fired by the pulverized fuel method. This supplementary market for mechanical firing is doubtless largely in the field of exceptionally large units. The final residue of about 20 per cent of this boiler firing market is probably being sold for the methods of gas and oil firing, and for hand firing. It is very interesting to note that stokers are maintaining their popularity as the major method for firing steam power boilers.

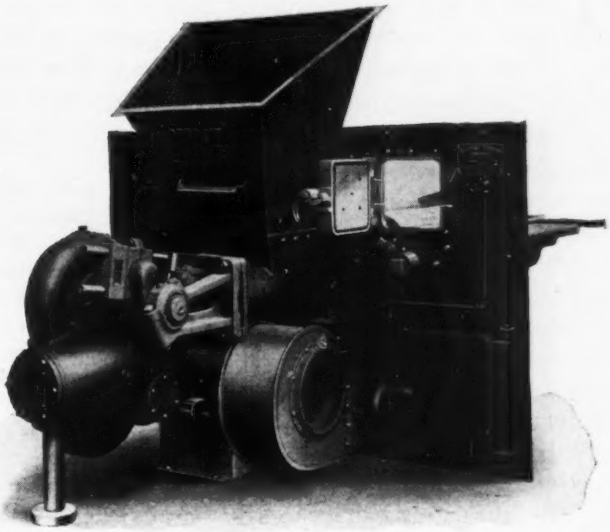


Fig. 13—Single retort stoker showing integral electric drive and fan

Fig. 12—Overfeed stoker with inclined grate

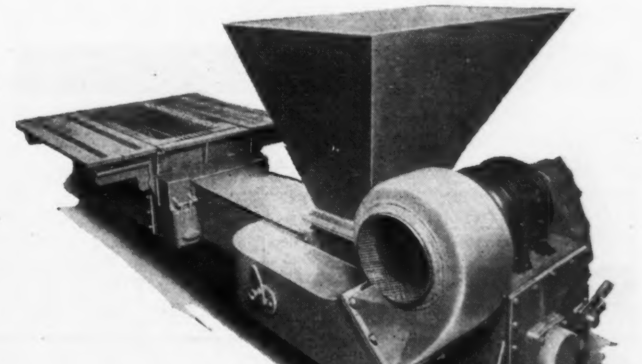


Fig. 14—Screw feed stoker with self contained fan and electric drive

The Influence *of* Modern Central Station Design Upon Industrial Power Plant Practice

By W. L. Fergus
Consulting Engineer, Chicago

> **There is need for stressing the difference between industrial and central station steam plant design. While the fundamental engineering principles are, of course, the same, the technique of their application requires what Mr. Fergus aptly designates as a "nice distinction" on the part of the designing engineer. The field of the industrial plant designer is very large, and the savings in coal consumption that he may make are enormous.**

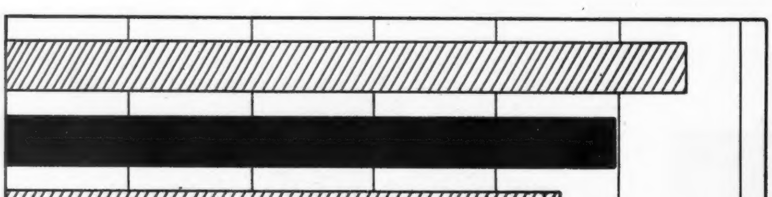
THE problem of the engineer engaged in designing power plants for industrials has some points of resemblance but more points of difference as compared to the problem of the utility plant designer. Presumably the two engineers had the same early training and obviously the same principles govern their design, but long before they were competent to undertake design their paths had entirely diverged.

The utility designer usually contends with the requirement of getting a tremendous output on a very limited ground area. The industrial man has little of this space restriction, and this difficulty can generally be made negligible by careful study. Industrial plants in many fields do not have the quick swings of load nor the wide variations in load that the utility man must meet. The utility man is designing a plant complete in itself which produces kilowatt hours. The industrial man is designing merely an auxiliary to a factory which produces some commodity with the help of certain kilowatt hours and also with the use of process steam. The heat balance does not in any way resemble that of a utility and is complicated by process demand over which the designer may have little control. Utility engineers ordinarily are free to invest in anything that will show a profit. The industrial man has to "sell" very thoroughly anything which will add to power plant investment. He is at all times confronted by the fact that he is not purchasing productive equipment.

With the tie-in of the modern utilities, a great part of their standby investment is being omitted and a much larger percentage of the equipment than will be permitted in the industrial plant can be in operation at practically all times.

In the greater number of industrial plants the question of heating is of as great or greater consequence than generating power. The designer of the larger plants is not ordinarily building a plant or a factory from the ground up, but is installing, perhaps in a new building, a plant to serve a relatively large factory with heating equipment already installed.

The industrial plant designer's hands are tied in the matter of equipment. The utility man can make a departure from customary practice with the full approval of his executives who know that this departure is something of a gamble even though the



Railroads	27.7 per cent
General manufactures, including steel	**24.9 per cent**
Domestic and miscellaneous	22.7 per cent
Coke ovens	16.0 per cent
Utilities	**8.7 per cent**
	100.0 per cent

Distribution of bituminous coal used in 1927 as reported by U. S. Department of Commerce

Fig. 1—Note the small percentage of coal used by the intensely developed utilities, and the comparatively large percentage by manufactures. This indicates the enormous field for fuel economy work by industrial power engineers

problem has been most carefully studied. If the experiment turns out well, an increase in efficiency, however slight, is of importance to the plant owners; if the scheme fails, the history of the failure is still an asset to the company that charges off the expense of the experiment. The client of the industrial man has no sympathetic interest in the history of failures, and when his engineer tries an experiment, he generally does it at his own risk. If it succeeds it was obviously the thing to do; should it fail it is equally obvious that he should have followed standard practice.

Industrial engineers receive no benefit from the rate making situation. Costly experiments can not be put into capital as a basis for charges but must be wiped out as a current expenditure. This situation means that experimental development work is necessarily done by the utilities and these experiments are made on large scale units. Perhaps the utility man would have preferred to try out his scheme on a smaller unit but these no longer exist.

Of recent years, utilities have made all of the forward steps. The first step was in the steam turbine itself, then in the use of higher pressures and higher temperatures. This was followed by the large units and by experiments with powdered coal, often in districts where stokers were giving satisfaction. Experiments were made with high superheat in utility plants where multi-stage bleeding and high vacuum were already giving the best known efficiencies.

With the high temperature and high pressure development, the utilities were also required to provide devices for meeting these conditions. Improved piping, valves and fittings had to be developed at the expense of millions of dollars, all borne by the utilities.

The industrial man is obligated not only for the development of all of this equipment but also for the publicity with which the utility engineers have laid before one another and before an engineering public the results of their work, and the industrial engineers have helped themselves to this wealth of information with gratitude

In the writer's opinion the development which has been of most value to the industrial plant is high pressure, which gives a wide selection of extraction conditions. The industrial plant designer has been able to utilize the central station information as far as the throttle of his turbine, and then to obtain, partly as the result of utility development, a turbine for relatively high pressure extraction and sometimes double extraction. These machines, which are now every-day practice in medium size industrials, are often the key to industrial power plant economy.

The information available to the industrial man has unfortunately in many cases gone to his head. Some of these designers have clearly gone utility crazy. Boilers have been installed for operation at capacities which, while reducing the first cost of the units, has created operating and maintenance problems that should not exist. Plants which should have been designed simply have had injected into them high efficiency complications which have brought maintenance and plant labor costs entirely out of line. Fuel burning schemes which were carefully studied and proved successful under utility conditions and for large capacities have been dragged out of their proper settings and placed in surroundings where they do not fit.

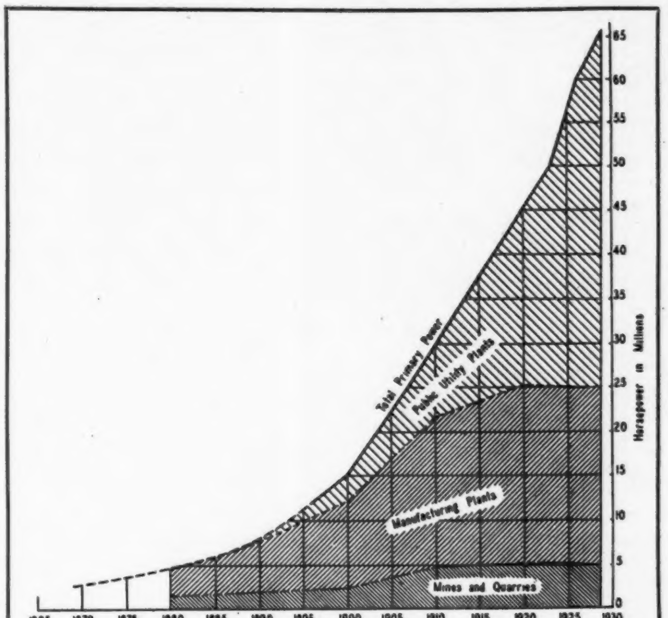


Fig. 2—Primary power in the United States. A comparison of the data in Fig. 1 with those in Fig. 2 indicates an average coal consumption in manufacturing plants about five times as high per primary horsepower as in utility plants

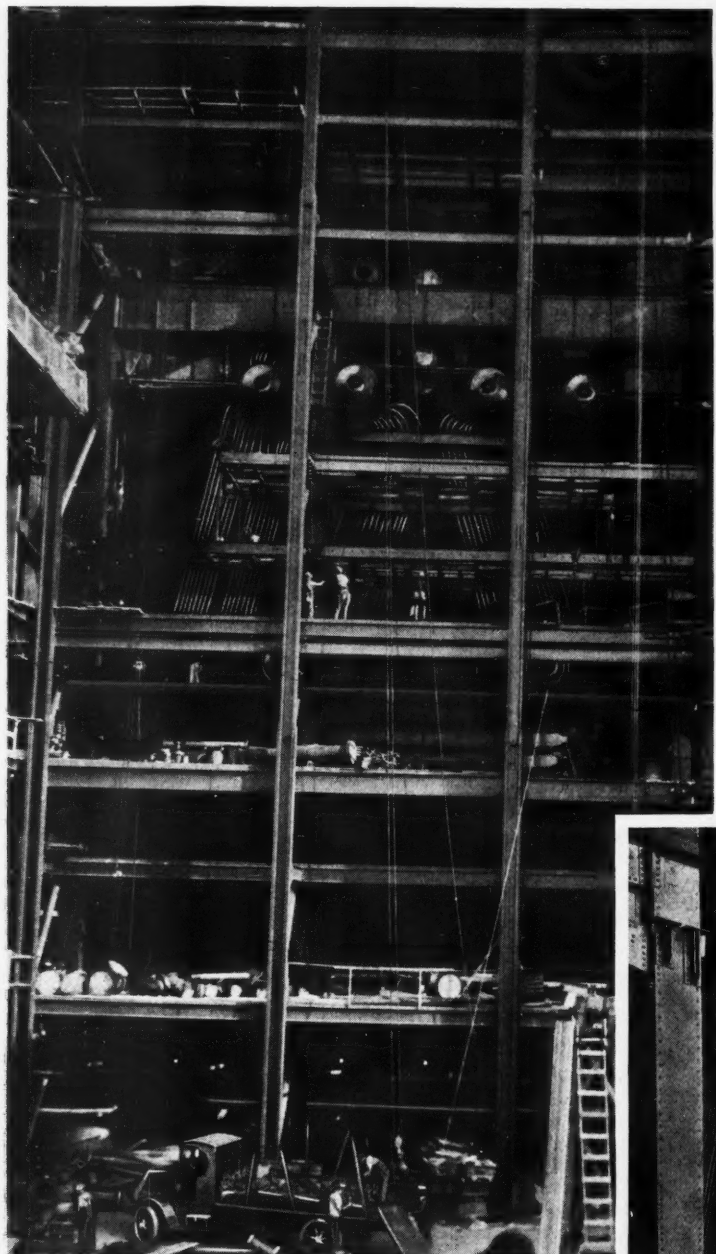
What is needed on the part of a good industrial power plant designer is fairly complete knowledge of what is being accomplished by the big fellows with a nice discrimination as to what part of this information can be profitably applied to his own problems. He needs an appreciation of the influence of load factor and a realization of the point that he is supplying only a contributing factor and not the main factory output. Some industrial plants are now of a magnitude that approaches central station conditions, but these plants are few, and industrial designers must realize that seldom can utility practice be copied bodily.

Meters in Chaldea

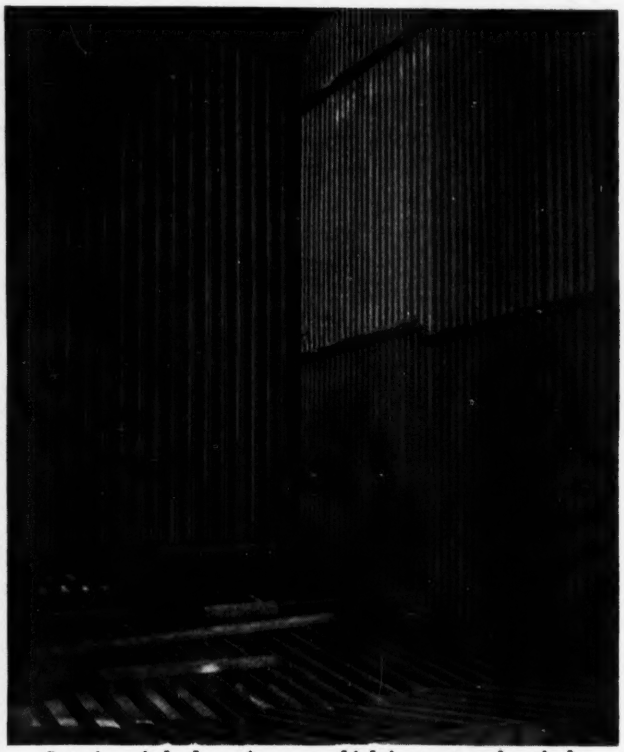
THERE is record that over 4,000 years ago the Chaldeans used the principle of water discharged through an orifice of a jar as a measuring device in their astronomical work. So accurate was their technique, that modern astronomers can find only a difference of 5 seconds in a period of about 19 years. The man who buys a steam flow meter today buys an ancient principle clothed in modern construction.

The World's Largest Steam Generating Unit *in* Operation

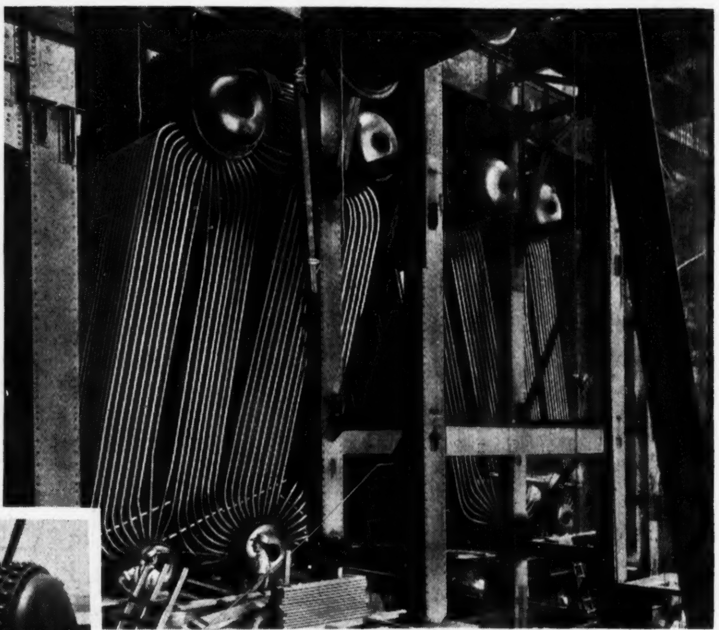
Construction views of one of three 800,000 lb. steam generating units at the East River Station of The New York Edison Company. This unit was completed and placed in operation during the past month.



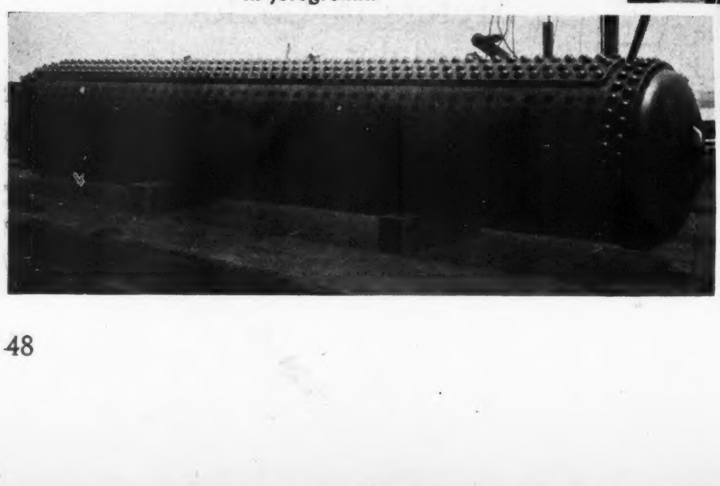
Note the height of the boiler structure by comparison with workmen near the boiler and with truck in foreground



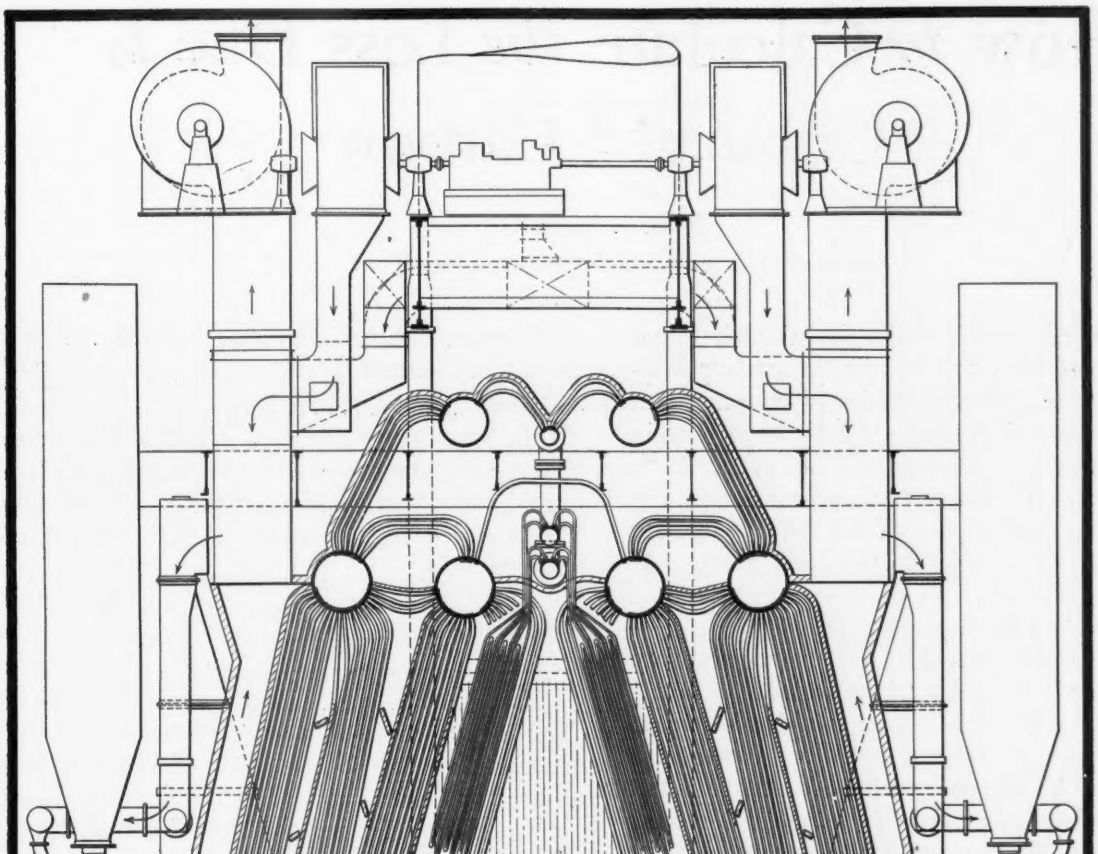
Interior of the huge furnace which is composed entirely of all metal heat absorbing surfaces. Water screen tubes are shown at bottom of furnace

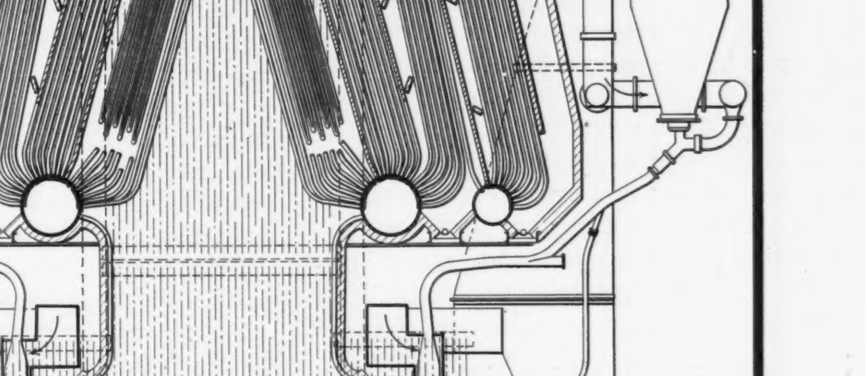


Above—Closer view of the boiler assembly. Note comparative size of men in lower left corner



Left—One of the huge boiler drums as delivered to the site





Sectional elevation showing boiler, water-cooled furnace, pulverized fuel firing equipment, fans, economizers, superheaters, and air preheaters, all arranged as a single coordinated unit. At the right is an exterior view of the East River Station

How *to* Calculate *the* Loss Due *to* Unburned Carbon

By B. J. Cross
Combustion Engineering Corporation, New York

THE unburned carbon of the fuel fired is found in the refuse from the ash pit, in settling hoppers such as are commonly provided under boiler passes, economizers and air preheaters, and in the dust and cinders that are carried out of the stack by the flue gases. In tests of stoker-fired boilers the loss due to carbon carried out of the stack is usually not calculated, but appears in the heat balance as an unaccounted for loss. At high ratings this dust and cinder loss may be considerable.

In a test conducted for results of extreme accuracy the refuse from all these locations should be determined. It is usually possible to weigh the refuse from the ash pit and settling hoppers. While the stack refuse may be determined by difference, it can be measured with reasonable accuracy by special sampling devices. In any event the attempt should be made to account for all of the ash as computed from the amount of fuel fired and its analysis.

Thus for a pulverized coal-fired installation, with a coal containing 10 per cent ash and fired at a rate of 5000 lb. per hour, the "ash balance" of the 500 lb. of ash might be calculated as follows:

Refuse in ash pit..................... 125 lb.
(Combustible 0 per cent, ash 100 per cent)
Refuse in economizer hopper .... 125 lb.
(Combustible 40 per cent, ash 60 per cent)

The ash content of economizer hopper refuse is $125 \times .6 = 75$ lb The ash accounted for in these two locations is thus 200 lb., leaving 300 lb. unaccounted for, which is assumed to go up the stack. If the stack dust analyses 20 per cent combustible, then the refuse up the stack will be $\frac{300}{1.00 - .20} =$ 375 lb., of which 20 per cent or 75 lb. is combustible, and 300 lb. is ash. The original ash in the coal is therefore distributed as follows:

In ash pit	125 lb.	2.5 per cent
In economizer hopper	75 lb.	1.5 per cent
Up stack	300 lb.	6.0 per cent
Total	500 lb.	10.0 per cent

In a stoker-fired installation, a typical distribution of ash would be as follows:

Refuse in ash pit..................... 470 lb.
(Combustible 20 per cent, ash 80 per cent)
Refuse in economizer hopper .... 125 lb.
(Combustible 40 per cent, ash 60 per cent)

The amount of ash may be tabulated:

Ash in ash pit, $470 \times .8$	376 lb.
Ash in economizer hopper, $125 \times .6$	75 lb.
Ash unaccounted for	49 lb.
Total	500 lb.

If the stack dust analyses 40 per cent carbon, the refuse up the stack would be 83 lb., of which 34 lb. would be combustible, and 49 lb. would be ash.

The original ash of the coal fired would be distributed:

In ash pit	376 lb.	7.5 per cent
In economizer hopper	75 lb.	1.5 per cent
Up stack	49 lb.	1.0 per cent
Total	500 lb.	10.0 per cent

The accompanying chart may be used for graphical determination of the loss in lb. of carbon per lb. of fuel fired, and the loss in B.t.u. per lb. of fuel fired.

In the example given for the pulverized fuel fired boiler, the ash content of the coal by analysis is 10 per cent. The average combustible content of the refuse is 20 per cent. To obtain the desired results from the chart, start from the 10 per cent ash point on the bottom horizontal scale, trace vertically to the 20 per cent combustible line; from this intersection trace horizontally to the right to the scale for loss of carbon per pound fuel; or, trace horizontally to the left to the diagonal, and from this intersection trace vertically to the top horizontal scale, which gives the loss in B.t.u. per pound fuel.

Care must be used in boiler test work not to use the total carbon in the fuel as fired for calculations of certain of the losses. For losses due to carbon monoxide, dry stack gases, and also for any other calculations involving the products of combustion, only the amount carbon actually burned must be used as the basis for figuring. This article shows how to calculate the amount of carbon not burned. When this amount is subtracted from the carbon actually in the fuel as fired, the resulting carbon is expressed by the symbol C_b. This distinction should be carefully noted in all of this work. The symbol C_b was used in the calculations for loss due to heat in dry flue gas, in COMBUSTION for August 1929, and will be used in certain future articles.

If it is desired to determine the loss in the ash pit, settling hoppers and stack gases separately, the same procedure is followed, using the portion of the ash and the per cent combustible in refuse at each location.

In this article the term "ash" means the ash in coal by analysis. The ash plus the combustible it may contain is termed "refuse."

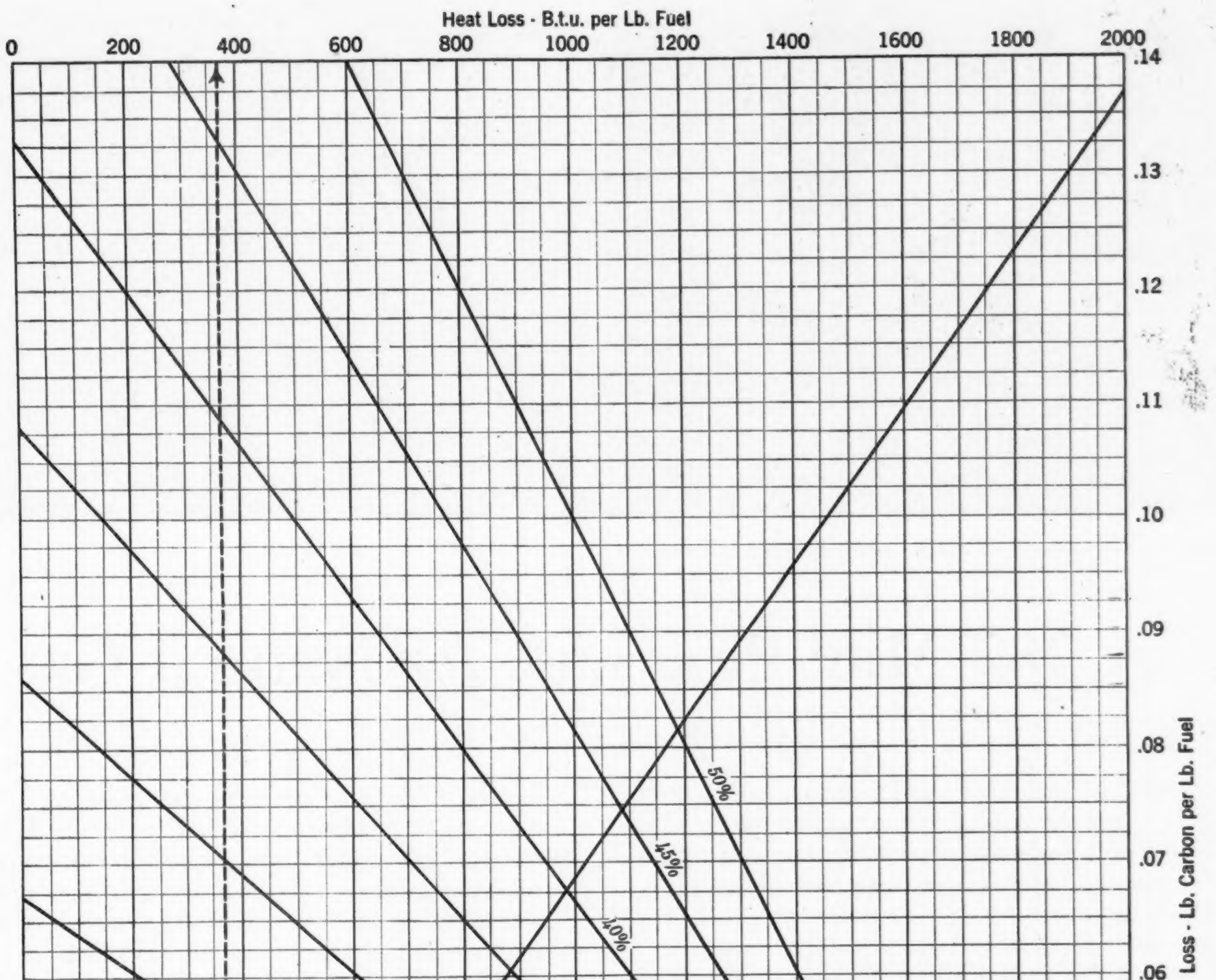


CHART FOR DETERMINING LOSS DUE TO UNBURNED CARBON

No. 4 of a series of charts for the graphical solution of steam plant problems

Welding a twenty-inch natural gas pipe line in level country

A 282 Mile Pipe Line *for* Natural Gas

By C. W. Geiger, San Francisco

THE oil fields of California are to yield their enormous flow of natural gas to industrial uses. San Francisco, Oakland, San Jose and adjoining territory will consume the gas from wells over 200 miles away.

Harnessing this natural supply is not a simple problem. The gas, at the wells, has a very high pressure, and a high heating value. It also has impurities, in the case of certain wells, while it is practically pure from others. All the variables must be harmonized and blended, in order to serve industry with a dependable product. There must even be a tie-in for blending with the regular manufactured gas, since the possibility of break-down must be taken into calculation.

But this is all being done, and the cities will soon be using natural gas for all the purposes of industry—for lighting and for cooking, for industrial heating furnaces, for melting furnaces, and even for blast furnaces.

The main transmission line will start at the gas wells in the Buttonwillow gas field where seven wells have been completed and are standing ready to deliver gas at 400 pounds pressure as soon as the pipe line is completed. This gas main will be sixteen inches in diameter and will extend northwesterly fifty-three miles to a point near the northern end of the Kettleman Hills. At this location, a large compressor plant will be built. The necessary connections will provide for a twenty-two inch diameter steel main to be laid northwesterly a distance of forty-one miles to a point southwest of Mendato, where the line will branch into two twenty-inch lines, provision being made to extend one twenty-inch line, at some later date, to serve points north. At the present time only one of the twenty-inch lines will be laid and this will extend northwesterly through Panoche Pass to Tres Pinos, Hollister, Gilroy, San Jose and terminate at Milpitas, a total distance of two hundred and three miles from Buttonwillow. At Milpitas, metering stations will be installed and a twenty-inch line has been laid northwesterly a distance of forty-four miles to the Potrero Gas Plant of the Pacific Gas & Electric Company in San Francisco. A second twenty-inch line has been laid northwesterly a distance of 35 miles to the Oakland Gas Works in Oakland, making a total of two hundred and eighty-two miles of natural gas transmission pipe lines.

At the present time, seven gas wells have been completed in the Buttonwillow area, showing well pressures of one thousand and fifty pounds and an estimated delivery capacity of thirty to fifty million cubic feet per day if required. In the Kettleman Hills, the Elliott No. 1 well has been producing about four thousand barrels of sixty gravity oil daily and more than forty million cubic feet of gas. A well pressure of twelve hundred and fifty pounds has been maintained for over ninety days. Plans have been completed for drilling twenty wells in this area, a number of these wells are now drilling and by the time the pipe line is

This is an interesting story of tapping Nature's reservoirs for the commercial needs of society. Here is a fuel that furnishes its own motive power for transportation over the several hundred miles between wells and cities.

completed several of them should be producing gas and oil. The Kettleman Hills productive oil zone is over seven thousand feet deep. Geologists agree that the Kettleman Hills and adjacent territory constitute one of the largest potential gas and oil reserves in California. Other wells being drilled between Buttonwillow and Kettleman Hills, and, for considerable distances east, show the presence of large quantities of gas. The large area over which gas has been found in this section makes certain a large supply for many years to come. All of this supply will be made available for the San Francisco Bay area.

The gas being produced in the Buttonwillow field is a dry gas, and has a heating value of approximately 1,050 B.t.u. per cubic foot. The gas in the Kettleman Hills area contains a large quantity of gasoline and is called a wet gas. It is necessary to remove the gasoline from the natural gas before turning the gas into the pipe line. In order to save this gasoline, the oil producers install gasoline absorption plants and deliver the natural gas to the pipe line practically dry. The gas from the Kettleman Hills wells will have an average heating value of between 1,200 and 1,250 B.t.u. per cubic foot after the gasoline is removed.

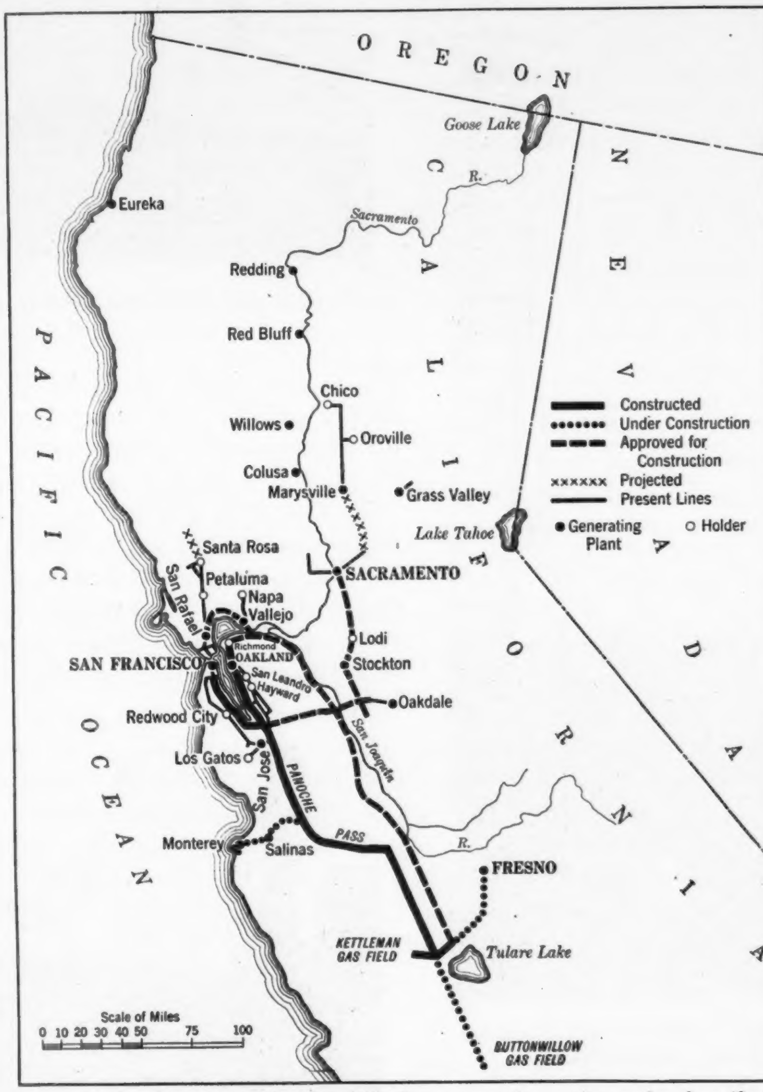


Fig. 1—Location in California of the long natural gas pipe mains described in this article

One of the most interesting problems was the determination of the proper kind of gas to be delivered for general domestic use. The pipe line being 247 miles long and consisting of only one main trunk at this time, made it hazardous to attempt to serve straight natural gas, as these pipe lines break at times despite the use of the best workmanship and materials. Service to more than 370,000 gas consumers would be interrupted if straight natural gas were supplied and any trouble developed with gas supply or pipe line.

Another serious difficulty to be overcome was the effect of straight natural gas on burners of appliances now being used with manufactured gas averaging 550 B.t.u. Every appliance would require adjusting and change of orifices in the burners. Many appliances would require new burners and considerable expense and inconvenience to consumers would be involved during the change over. Many other difficulties are encountered in turning natural gas into a manufactured gas distributing system, such as meter deterioration and increase in leakage due to the action of natural gas on the deposits left by manufactured gas.

After considering all these difficulties, it was decided to deliver a mixed gas of 700 B.t.u. heating value instead of the 550 B.t.u. gas as now served to domestic consumers. Straight natural gas will be supplied only to industries on shut-off contracts, where oil burners can be used for short periods in event of any interruption to the gas supply. When this pipe line is completed all consumers from San Jose north to San Francisco and Oakland will be served a mixed gas having twenty-seven per cent more heat available than the present gas now being supplied.

Extensive changes are necessary in the gas-generating plants at Potrero and Oakland in order to produce the new 700 B.t.u. gas. A 10,000,000 cubic foot holder is being erected to store natural gas at the Potrero works to insure an adequate supply of natural gas for mixing and for gas manufacturing. Automatically controlled mixing devices will be installed to maintain a gas of uniform heating quality. An 8,000,000 cubic foot storage holder will be constructed at Gas Station "B" Oakland.

Service of the 700 B.t.u. mixed gas requires the operation of the generating plants at about half the capacity now operated. Natural gas will be used in the generators in the place of oil now used. The gas manufactured from the natural gas will be mixed

with natural gas so that the gas delivered to the customer will be spoken of as a "mixed gas," the proportions being such as to provide a 700 B.t.u. gas for distribution. The San Jose, Oakland and San Francisco gas plants will operate on a mixed gas basis.

The extent of this pipe line involves a huge problem in welding, and various sections were handled by different organizations. Some 62 welders were used by the Gas and Electric Company on the 76 mile

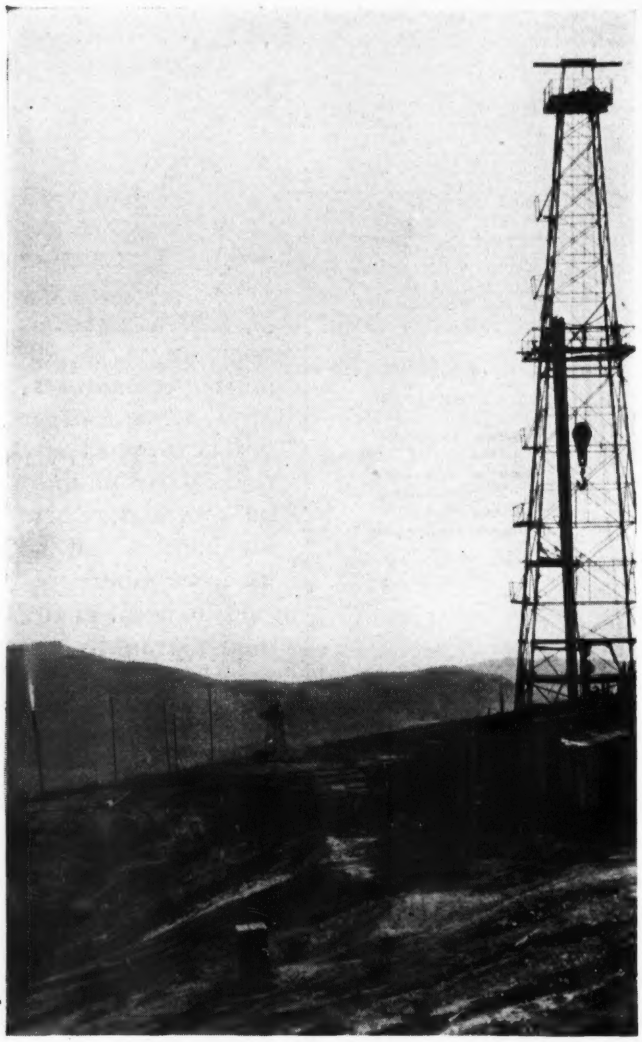


Fig. 2—Typical scene in the natural gas field in California, whence the gas is piped nearly 300 miles to San Francisco

section which the company built itself, while the rest of the actual pipe line was handled by contractors. Forty-one thousand tons of pipe were manufactured by the A. O. Smith Corporation of Milwaukee and a considerable tonnage by the Western Pipe and Steel Company of South San Francisco. The total expenditure by the Pacific Gas and Electric Company in making natural gas available for customers throughout its system amounts to some $26,000,000.

All the field joints were welded by the oxy-acetylene process. The Oxweld Acetylene Company's special alloy steel welding rod known as Oxweld No. 1 Highest Rod was used as a filler material on all Oxwelded joints.

The pipe was manufactured from steel having approximately 65,000 lb. tensile strength, and after suitable tests it was determined to use this special "highest rod" in order to secure a welded joint which would develop the full strength of the pipe.

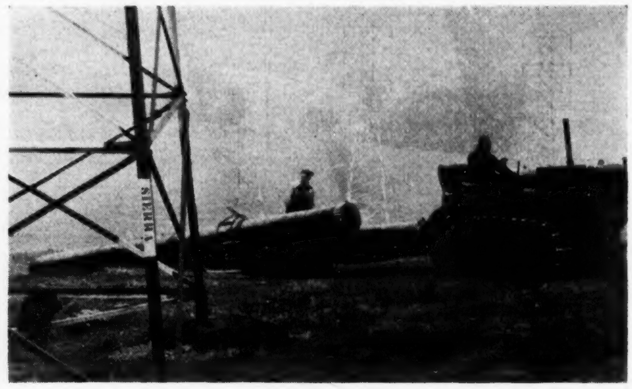


Fig. 3—Handling heavy steel pipes in field on sledges drawn by caterpillar tractors

The 30 foot pipe sections were welded into 90 or 120 foot lengths and these long sections were then picked up by truck crane and lowered onto heavy timbers placed across the top of the trench.

As a method of construction procedure, the welding crews worked at welding pipe sections for one day, after which test heads were installed in each end of the day's weld which was then put under air pressure. The soap bubble test was applied, and if no leaks were found the recording pressure gage was

Fig. 4—From three to five sections of the large pipe were first welded together above ground, and then handled into the trench with a truck crane

connected and the section kept under pressure for from 12 to 24 hours. If no drop in the pressure was found, the air was released and the section welded to the previously welded section. If a leak was found in any of the joints the line was blown down and the leak welded. Then the line was put under pressure again and left for 12 to 24 hours. This method of construction proved both satisfactory and economical, and progress at the rate of 3 miles per day was often made.

• NEWS •

John Anderson Dies

JOHN ANDERSON

JOHN ANDERSON, Vice-President of The Milwaukee Electric Railway & Light Company, died at St. Mary's Hospital, Milwaukee, on Monday, October 14th, at the age of 57 years. Mr. Anderson's death was the result of a blood infection contracted during a recent illness.

Mr. Anderson was generally regarded as one of the outstanding public utility engineers of the country. In his death, the engineering field loses a real pioneer and a man of exceptional achievement. Mr. Anderson became identified with The Milwaukee Electric Railway & Light Company in 1912 as Chief Engineer, and held that position until he was made Vice President in Charge of Power in 1925. He was one of the first public utility engineers to sense the possibilities of pulverized fuel. The first commercial installation of this method of burning fuel in a central station plant was made under his direction at the Oneida Street Station in 1918, and the development work conducted at this plant helped in a very large measure to establish pulverized fuel as the most efficient method of coal combustion.

Mr. Anderson was also one of the first public utility engineers to install high pressure boilers. His installation of a 1400 lb. pressure steam generating unit at the Lakeside Station in 1926 was an important pioneering step in this direction, which gave great impetus to the trend toward high pressures.

Mr. Anderson was born in Aberdeen, Scotland, and educated at the British Government School of Science & Technology, Liverpool. His early engineering training was on board ship, where his marked ability as an engineer won him rapid promotion. Prior to the time of his entry into the stationary plant field, he was Chief Engineer of the St. Paul, which was then the largest and swiftest American vessel.

Mr. Anderson was identified with a number of engineering societies, and gave largely of his time and ability to association work. His many important contributions to the advancement of power plant engineering will create a permanent place for him in the annals of engineering achievement.

Engineers Public Service Reports New Contract

C. W. KELLOGG, president of Engineers Public Service Company, recently announced the completion of negotiations with the Standard Oil Company of Louisiana, one of the most important subsidiaries of the Standard Oil Company of New Jersey, covering the supply to the Standard Oil Company's large refining plant at Baton Rouge of substantially the entire steam and electric requirements of this plant.

Louisiana Steam Products, Inc., of Baton Rouge, La., a newly formed subsidiary of the Engineers Company, will build at once a boiler plant capable of supplying the estimated refining plant demand of over 6,000,000,000 pounds of steam per annum and an electric generating plant of 45,000 kw. capacity to cost approximately $6,000,000. The gross business covered by the contract with the Standard Oil Company is estimated to be $1,600,000 annually.

The Pennsylvania Railroad Company, Philadelphia, has awarded a contract to Gibbs & Hill, Inc., New York, for the construction of the distribution and transmission systems for the electrification of the Pennsylvania's New York division between New York City and New Brunswick, N. J. This includes the transmission lines, sub-stations, catenary supporting structures, overhead wires and bonding. The contract covers a part of the Pennsylvania lines to be electrified under the $100,000,000 program announced last year by General W. W. Atterbury, president. Work has been under way for several months on the section between North Philadelphia, Pa., and Trenton, N. J., and is about one-third completed.

The completion of a new 20-inch gas distribution pipe line ten miles long connecting the plant of the Philadelphia Coke Company with the Point Breeze plant of the Philadelphia Gas Works, is announced by Eastern Gas and Fuel Associates, a Massachusetts voluntary trust recently formed by the Koppers interests. The Philadelphia Coke Company is a subsidiary of Eastern Gas and Fuel Associates, and sells its coal gas production under long term contract to the Philadelphia Gas Works, which serves Philadelphia.

H. E. Brelsford, formerly Chief Engineer of the Technical Department of the United States Shipping Board, and more recently Works Manager of the Buffalo Works of the Worthington Pump & Machinery Corporation, is now associated with the Diamond Power Specialty Corporation of Detroit, Mich., in charge of the Research Department.

N.E.L.A. Convention at San Francisco

THE National Electric Light Association has announced that the 53rd convention of the Association will be held in San Francisco from Monday, June 16, 1930, to Friday, June 20th. The convention will be held in the Municipal Auditorium. Consideration is being given to holding an exhibition of power plant machinery, equipment and appliances in connection with the convention. As this will involve the erection of a temporary structure for housing the exhibit, final decision on this point probably will not be made for several weeks.

For many years it has been customary for the Association to hold a convention on the Pacific Coast, once every five years, having met in San Francisco in 1925, in Pasadena in 1920, and in San Francisco in 1915 during the World Fair.

National Industrial Exposition at Chicago

"WASTE must go," is the slogan for the National Industrial Exposition to be held in Chicago, March 3 to 7, 1930, according to a recent announcement. Labor saving and material handling equipment, new construction materials and designs, power transmission and connections, safety devices and many other factory and industrial appliances will be on display.

The National Industrial Show is planned to present an opportunity for keeping in touch with the progress in the many phases of industry and to give an up-to-the-minute viewpoint of modern industrial efficiency.

Gas Sales Increase 12 Per Cent

GAS utility sales during August were 12 per cent greater than those of the corresponding month in 1928, according to Paul Ryan, statistician of the American Gas Association. The customers of the reporting companies, representing about 80 per cent of the industry, aggregated 9,282,968 at the end of August, a gain of 2.4 per cent over a year ago.

In New England, sales of gas for all purposes registered an increase of over 9 per cent for the month of August and of nearly 6 per cent for the eight months ended with August. In this section, as throughout the country generally, the most marked expansion occurred in sales of gas for industrial-commercial purposes. Industrial-commercial gas sales in New England registered a 12 per cent increase in August and a 7.2 per cent increase for the eight-month period.

Milwaukee Electric to Build New Steam Plant

THE power capacity of the Wisconsin-Michigan group of subsidiaries of the North American Company will be increased by a new steam-electric generating plant to be built by the Milwaukee Electric Railway & Light Company on the shore of Lake Michigan, 28 miles north of Milwaukee at Port Washington, Wis. The initial investment will approximate $8,000,000, and the ultimate expenditure will exceed $25,000,000. The initial rating will be 60,000 kw., and the plans provide for an ultimate capacity of 300,000 kw.

Construction will begin early in 1930. The plant will be similar in operating characteristics to the present Lakeside plant at Milwaukee.

Nevin E. Funk, formerly assistant general manager, Philadelphia Electric Company, has been elected vice-president in charge of engineering. Mr. Funk has been associated with the Philadelphia Electric Company for 22 years, and has served successively as assistant operating engineer, operating engineer, assistant chief engineer, chief engineer, and assistant general manager.

Mr. Funk has taken a prominent part in the affairs of the many engineering organizations to which he belongs.

Combustion Engineering Corporation, New York, announces the receipt of award for the complete fuel burning and pulverizing equipment for six 3256 hp. boilers to be installed in the Ashtabula plant of the Cleveland Electric Illuminating Company.

In this new installation 195,360 square feet of boiler heating surface will be fired by the Lopulco Pulverized Fuel Systems and approximately 2,700,000 lb. of steam per hour will be generated by these units.

Other stations of the Cleveland Electric Illuminating Company in which Lopulco Pulverized Fuel Systems are installed include the Avon Station, Twentieth Street and Seventieth Street Station in Cleveland.

Howard Butt, formerly sales manager of the Air Preheater Corporation, is now connected with the Hahn Engineering Co., a division of the Lancaster Iron Works, Lancaster, Pa.

The smokeless fuel problem ought to be solved in India. A recent report relates the discovery of some 25 million tons of marketable coke that may be mined just like coal. The Indian name for this fuel is "jhama", which means burnt coal. It is a natural metallurgical coke, and, of course, may find its logical market in the steel industry of India.

NEW CATALOGS AND BULLETINS

Any of the following literature will be sent to you upon request. Address your request direct to the manufacturer and mention COMBUSTION Magazine

Arc Welders

The new improved Lincoln "Stable-Arc" Welders are shown and described in a new folder. Both portable and stationary welders are presented and these are available in motor driven, gasoline engine driven or belt driven types. 4 pages, 8½ x 11—The Lincoln Electric Company, Cleveland, Ohio.

Boiler Baffles

"Modern Baffles for Bent Tube Boilers" is the title of Bulletin G which describes Interlocking Sectional Tile Baffles. A tongue and groove construction is provided so that no cement is required at the joints. The tile are shown in detail and one typical baffle arrangement is illustrated. 4 pages, 8½ x 11—Power Plant Efficiency Co., Union Title Building, Indianapolis, Ind.

Chain Grate Stokers

Green Natural Draft Chain Grate Stokers are illustrated and described in a new catalog GND 2. The salient features of design are outlined and numerous illustrations show the details of construction. A series of line drawings present various setting arrangements applicable to different types of boilers and ash pit layouts. The results of three different tests are given covering various kinds of coal and operating conditions. An impressive list of installations is included. 28 pages and cover, 8½ x 11—Combustion Engineering Corporation, 200 Madison Ave., New York.

Flow Meters

"Why you should use Flow Meters," is the title of a new catalog which presents in an impressive manner, the need of proper instruments in the modern steam plant. 24 ways in which Flow Meters can reduce steam costs, are discussed and illustrated. The principles of operation and details of construction of the Brown Electric Flow Meter are briefly described. 52 pages and cover, 8½ x 11—The Brown Instrument Company, Wayne and Roberts Aves., Philadelphia, Pa.

Furnace Wall Construction

The Drake "Thermo-Fit" waterwall block is described in Bulletin No. 106. This water cooled furnace wall consists of the conventional tubes, headers and circulators. The tubes exposed to the furnace are covered with "Thermo-Fit" blocks which provide a complete furnace lining of cast iron, forged or refractory faced blocks (or a combination), the choice depending on the furnace temperature and the rate of heat absorption desired. Several charts are included to show absorption rates and furnace temperatures under various conditions. 8 pages, 8½ x 11—Drake Non-Clinkering Furnace Block Company, 5 Beekman Street, New York.

Machinery Isolation

A new folder describes the characteristics and use of Armstrong's Cork Machinery Isolation for deadening the vibration and noise incident to the operation of all types of machines. The material is a resilient board made by baking, under pressure, a selected grade of granulated cork. Three densities, light, medium and heavy are available. Considerable information is presented relative to the use of the material and line drawings illustrate typical applications. 6 pages, 8½ x 11—Armstrong Cork and Insulation Company, Lancaster, Pa.

Pipe Gaskets

A new folder presents Kell-Raph copper plated steel gaskets which are applicable to all kinds of piping joints—including Van Stone joints, double recess joints and double groove joints. The gasket is a seamless steel ring of sufficient strength to withstand the internal pressure and prevent the gasket from blowing out. The plating may be copper or any other metal which will resist the action of the fluid to be handled and which will be soft enough to make a tight joint. 4 pages, 8 x 9½—The M. W. Kellogg Company, 225 Broadway, New York.

Power Plant Equipment

Bulletin S-10 is a Condensed Catalog of Swartwout power plant equipment. Brief descriptions and illustrations of apparatus are grouped under seven headings: Feed Water Regulation, Pressure Regulation, Condensation Control, Entrainment Removal, Water Purification and Heating, Ventilation and Baking and Drying. Separate Catalogs describing each product in detail are also available and all are punched for inserting in a loose leaf binder which contains a total of over 125 pages, 8½ x 11—The Swartwout Company, 18511 Euclid Avenue, Cleveland, Ohio.

Steam Flow Meters

The Foxboro Steam Flow Meter is presented in new Bulletin 162. This meter translates the pressure difference on the two sides of an orifice, into a direct reading and recording of steam flow. A simple and accurate integrating devise is also provided. The principle of operation and details of construction are fully illustrated and described. Typical application arrangements and piping layouts are shown. A section of the catalog briefly describes other Foxboro instruments. 32 pages and cover, 8½ x 11—The Foxboro Company, Foxboro, Mass.

Steam Generating Equipment

General Condensed Catalog GC-5 presents brief descriptions of the entire line of Fuel Burning and Steam Generating equipment manufactured by Combustion Engineering Corporation, including both storage and direct fired pulverized systems, six types of mechanical stokers, air preheaters, water cooled furnaces and a complete range of steam boilers. The catalog is well illustrated with photographs of apparatus and line drawings showing details and application arrangements. 16 pages and cover, 8½ x 11—Combustion Engineering Corporation, 200 Madison Ave., New York.

Steam Purifiers

Cochrane Steam Purifiers are covered by a new Bulletin 684 which emphasizes the need of purifying steam to protect superheaters, turbines and other apparatus from water and solids carried over with the steam. The requirements of steam purifiers and a detailed description of the Cochrane purifier are presented. Tabulated data and the results of numerous tests are included. 24 pages, 8½ x 11—The Cochrane Corporation, 17th and Clearfield Streets, Philadelphia, Pa.

Soot Blowers

Diamond Automatic Valved Soot Blowers are illustrated and described in Bulletin No. 347. The catalog is profusely illustrated in two colors to show the details, operation and application of Diamond Soot Blowers. The Dialoy element, developed by the Diamond Company is described as being particularly free from warping and possessing great strength and long life at the high temperatures now encountered in the tube banks of modern boilers. Numerous charts are included to emphasize the value of proper soot cleaning. 36 pages and cover, 8½ x 11—Diamond Power Specialty Corporation, Detroit, Mich.

Soot Cleaners

Vulcan Soot Cleaners are presented in a new two color catalog. The advantages and requirements of mechanical soot cleaning are briefly described, followed by detailed descriptions of the various types of Vulcan mechanical cleaners and their application. Fifty line drawings are included to illustrate the proper location of the cleaning elements in various types of boilers. A number of plant reports are reproduced to show savings made by proper soot cleaning. 40 pages and cover, 8½ x 11—Vulcan Soot Cleaner Company, DuBois, Pa.

Valves

Catalog No. 60 lists the full line of Foster Valves and Steam Specialties including—pressure-reducing regulators, expansion valves, automatic relief valves, pump governors, pressure-control check valves, fan-engine regulators, vacuum breaker valves, free-exhaust valves, cushioned check valves, non-return valves and pilot valves. A section of tables and engineering data is also included. 100 pages and cover. 8½ x 11—Foster Engineering Company, 109 Monroe St., Newark, N. J.

NOTICE

Manufacturers are requested to send copies of their new catalogs and bulletins for review on this page. Address copies of your new literature to

COMBUSTION

200 MADISON AVE., NEW YORK

REVIEW OF NEW TECHNICAL BOOKS

Any of the books reviewed on this page may be secured through In-Ce-Co Publishing Corporation, 200 Madison Avenue, New York

Mechanical Equipment of Buildings

By L. A. Harding and A. C. Willard

THE authors of this work have gathered in Volume I an immense amount of valuable material on the subject of heating and ventilating. This volume has reached a second edition, lately revised, and is the book referred to in this review. As a reference book it will be of the utmost value to all engineers and authors who must, either occasionally or frequently, refer to the vast variety of technical matters involved in heating and ventilating.

In the first three chapters, constituting about 10 per cent of the book, the reader will find a clear and very useful exposition of the mathematical and physical aspects of steam, water, air and fuels. Numerous examples illustrate all sorts of customary problems.

The methods and apparatus for all the modern forms of heating are thoroughly covered in the body of the book. Such subjects as electric heating, air conditioning, humidity control and central station heating are all fully treated. There is a separate chapter on the preparation of plans, specifications and estimates, and another interesting chapter on estimating seasonal heating requirements for various types of buildings. The chapter that includes ventilation laws will prove of the utmost value.

There are about 950 pages, bound in semi-flexible covers. The volume is 7 x 9¼ in size and about 1½ in. thick, and is priced at $10.00.

Handbook of Chemistry and Physics

By Charles D. Hodgman and Norbert A. Lange

WHENEVER there is need to look up specific information regarding the chemical and physical characteristics of either the simple or the complex materials of the mechanic arts, this book will be consulted. It is not encyclopedic in the sense of describing fully all such materials; but the particular sort of information that it supplies is extremely complete.

Nearly all the information is in tabular form, which is substantially an index system in itself. In these tables are such items as the chemist and physicist will be most apt to want. Molecular weights are carried out to the second decimal place. Organic, as well as inorganic compounds, are exhaustively listed, with much detail of solubility, boiling and melting points, specific gravity, and the like. Then there is a series of tables giving the gravity and other information for a wide range of aqueous solutions.

For the physicist there are tables of the properties of matter—density, compressibility, viscosity, expansion, specific heat, electromotive force, wave lengths, and a great number of other special properties. The data on heat covers about 75 pages and is followed by hygrometric and barometric tables. Sound, electricity and magnetism are represented in many convenient classifications. About 100 pages are devoted to tabulated data on light, with many tables on refraction, wave lengths, radio activity, etc.

There is also a brief listing of the leading mathematical formulas required in chemical and physical research, with lists of concise definitions, and the usual tables of trigonometrical functions, logarithms, and useful numerical constants. Radio, physical and chemical formulas are also tabulated for convenient reference, and some exemplary problems are worked out.

The book is bound in flexible leather, in 4½ x 7 size, and its twelve hundred odd pages of thin paper are less than 1⅜ in. total thickness, making a very handy volume. The edition on hand is right up-to-date, and is priced at $5.00.

Gas Chemists' Handbook

By American Gas Association

WHILE this book is written particularly for the use of the gas industry, there is, nevertheless, considerable of value in it to the man who regards gas making as coming continually into closer alliance with steam making. There is, furthermore, a section on the subject of coal and coke that will appeal even more directly to the steam or combustion engineer. This section treats at considerable length of the various methods for testing fuel samples. Each method is described in precise detail, with full directions for carrying out complete fuel tests.

The method of treatment throughout the volume is accurately and precisely to describe the chemical analyses required of the chemist in the gas industry. That this treatment is authoritative may be confidently assumed, since the American Gas Association has revised the present edition through their Committee on Analysis, Tests and Editing Gas Chemists' Handbook, of which A. F. Kumberger is Chairman.

The book is 6½ x 9¼ size, with about 800 pages, and is bound in cloth. The price is $7.00.

PATENTS

Recently granted, and of Interest to our Readers.

Printed copies of Patents are furnished by the Patent Office at 10 cents each. Address the Commissioner of Patents, Washington, D. C.

UNITED STATES PATENTS

Issued September 10, 1929

17,427. Apparatus for Handling Powdered Fuel. Milton W. Arrowood, New York, N. Y. Filed September 7, 1928. Original application filed March 14, 1923. Divided and this application filed Jan. 16, 1924.

1,727,403. Condenser. John A. Gibb, New York, N. Y., assignor to Petroleum Derivatives, Incorporated, Portland, Maine, a Corporation of Maine. Filed May 7, 1927.

1,727,458. Steam Generator. Earl Vernon Varcoe. Philadelphia, Pa. Filed Sept. 30, 1924. Renewed Feb. 12, 1929.

Issued September 17, 1929

17,433. Condenser. Raymond N. Ehrhart, Pittsburgh Pa., assignor to Elliott Company, Pittsburgh, Pa., a Corporation of Pennsylvania. Filed March 11, 1927.

1,728,177. Heater. Raymond N. Ehrhart, Edgewood, Pa., assignor to Elliott Company, Pittsburgh, Pa., a Corporation of Pennsylvania. Filed Dec. 19, 1921.

1,728,248. Bushing-Removing Tool. Mitchell Naggy and Stanley Sikorski, Port Richmond, Va. Filed July 21, 1927.

1,728,375. Process of Utilizing the Heat of the Generator of Superpressure Steam Generators. Waldemar Stender, Berlin-Charlottenburg, Germany, assignor to Siemens-Schuckertwerke Gesellschaft mit beschränkter Haftung, Berlin-Siemensstadt, Germany, a Corporation of Germany. Filed Dec. 1, 1926; and in Germany Dec. 4, 1925.

1,728,423. Fuel Pulverizer. Henry G. Lykken, Minneapolis, Minn. Filed June 12, 1924.

1,728,513. Automatic Boiler-Compound Feeder. Robert R. Smiley, Marinette, Wis., assignor to Sca-Lax Laboratories, Inc., Green Bay, Wis. Filed April 30, 1928.

1,728,733. Fluid Heater. Edwin Jowett, Kansas City, Mo., assignor to the Babcock & Wilcox Company, Bayonne, N. J., a Corporation of New Jersey. Filed Dec. 27, 1923.

Issued September 24, 1929

1,728,913. Coal-Gas Converter for Furnaces. Charles Baier, West Orange, N. J. Filed June 2, 1928.

1,728,958. Rotary Furnace. William M. Duncan, Alton, Ill. Filed May 14, 1926.

1,728,976. Apparatus for Pulverizing Coal. Harry M. Nobis, East Cleveland, Ohio. Filed Oct. 3, 1927.

1,729,022. Furnace for Burning Finely-Divided Fuel. Wilfred R. Wood, London, England, assignor to International Combustion Engineering Corporation, New York, N. Y., a Corporation of Delaware. Filed June 16, 1925.

1,729,024. Method of Burning Pulverized Fuel. John E. Bell, Brooklyn, N. Y., assignor to Combustion Engineering Corporation, a Corporation of New York. Filed Dec. 9, 1921.

1,729,032. Feeder. Bertram J. Cross, Piermont, N. Y., assignor to International Combustion Engineering Corporation, New York, N. Y., a Corporation of Delaware. Filed Aug. 18, 1926.

1,729,037. Boiler Arrangement. Hermann Fecht, Berlin, Germany, assignor to Kohlenscheidungs-Gesellschaft m. b. H., Berlin, Germany, a Corporation of Germany. Filed Dec. 8, 1925; and in Germany Dec. 11, 1924.

1,729,056. Means for Impregnating Articles with Synthetic Resins. Daniel Armand Lucien Texier, Neuilly-sur-Seine, France. Filed Nov. 21, 1925; and in France and Great Britain Oct. 27, 1925.

1,729,057. Means for Impregnating Articles with Synthetic Resins. Daniel Armand Lucien Texier, Neuilly-sur-Seine, France. Filed Nov. 21, 1925; and in France and Great Britain Oct. 27, 1925.

1,729,074. Humidifying System. Alfred F. Karlson, North Leominster, Mass., assignor to Parks-Cramer Company, Boston, Mass., a Corporation of Massachusetts. Filed Mar. 5, 1928.

1,729,101. Combustion-Promotion Device. Albert French, Brooklyn, N. Y. Filed Mar. 17, 1927.

1,729,136. Automatic Control Apparatus. Irving B. Smith, Ambler, Pa., assignor to Leeds & Northrup Company, Philadelphia, Pa., a Corporation of Pennsylvania. Filed June 24, 1925.

1,729,151. Fuel Combustion. Herbert R. Brunner, New York, N. Y. Filed Oct. 7, 1925.

1,729,180. Hollow Article and Method of Making the Same. Thomas E. Murray, New York, N. Y., assignor to Metropolitan Engineering Company, Brooklyn, N. Y., a Corporation of New York. Filed Apr. 20, 1923.

1,729,217. Powdered-Fuel Furnace. Carl Hufschmidt, Westenfeld, near Wattenscheid, Germany. Filed July 27, 1927, and in Germany Oct. 3, 1925.

1,729,259. Steam-Boiler Economizer. David S. Jacobus, Jersey City, N. J., assignor to the Babcock & Wilcox Company, Bayonne, N. J., a Corporation of New Jersey. Filed Sept. 4, 1918. Renewed Dec. 13, 1927.

1,729,260. Steam Boiler. David S. Jacobus, Jersey City, N. J., assignor to the Babcock & Wilcox Company, Bayonne, N. J., a Corporation of New Jersey. Filed Sept. 14, 1923. Renewed May 1, 1928.

1,729,408. Smelting Furnace and Method of Smelting. Richard A. Wagstaff, Salt Lake City, Utah, assignor to American Smelting and Refining Company, New York, N. Y., a Corporation of New Jersey. Filed June 27, 1925.

1,729,411. Furnace. William M. Akin and Lafayette Young, Alton, Ill., assignors to Laclede Steel Company, St. Louis, Mo., a Corporation of Missouri. Filed Oct. 24, 1927.

1,729,418. Vertical Retort for Use in the Distillation of Shale and Like Materials. Robert Henry Crozier, London, England. Filed July 7, 1925; and in Great Britain Oct. 7, 1924.

1,729,471. Pulverizer. Grover E. Bear, Allentown, Pa. Filed May 10, 1926.

1,729,487. Sectional Boiler Header. Edwin C. Ramage, Jr., Charleston, W. Va. Filed Oct. 18, 1927.

1,729,545. Washing Apparatus for Separating Coal and Like Materials. Charles Marchant, Montigny-le-Tilleul, Belgium. Filed Dec. 7, 1926; and in Belgium Jan. 16, 1926.

1,729,562. Removal of Naphthalene Constituents from Gases. Eugene H. Bird, Pittsburgh, Pa., assignor to the Koppers Company, Pittsburgh, Pa., a Corporation of Pennsylvania. Filed Feb. 13, 1923.

Issued October 1, 1929

17,449. Baffle Wall. John E. Muhlfeld, Scarsdale, N. Y. Filed Sept. 18, 1928.

1,729,603. Apparatus for Handling Ashes or Other Solid Materials. Frank B. Allen, Lower Marion Township, Allegheny County Pa., assignor to the Allen-Sherman-Hoff Company, Philadelphia, Pa., a Corporation of Pennsylvania. Filed Dec. 23, 1926.

1,729,672. Coal-Pulverizing Machine. Ralph Jackson, Coventry, England, assignor to Alfred Herbert, Limited, Butts, Coventry, England, a British Company. Filed Apr. 12, 1926; and in Great Britain May 2, 1925.

1,729,700. Combustion Control. Merrill G. Benjamin, Lakewood, Ohio, assignor to Bailey Meter Company, a Corporation of Delaware. Filed Mar. 22, 1924.

1,729,750. Water-Cooled Port for Open-Hearth Furnaces. Samuel B. Sheldon, Duluth, Minn. Filed May 4, 1927.

1,729,763. Apparatus and Method of Fuel Burning. Luis De Florez, Pomfret, Conn., assignor to The Texas Company, a Corporation of Delaware. Filed Nov. 2, 1925.

1,729,776. Furnace. Wilfred A. Hare, Detroit, Mich. Filed Feb. 8, 1926.

1,729,837. Steam Superheater. Leon T. Mart, Kansas City, Mo. Filed Oct. 9, 1924.

1,730,243. Furnace. Lemuel V. Reese, Erie, Pa., assignor to Erie City Iron Works, Erie, Pa., a Corporation of Pennsylvania. Filed Dec. 22, 1926.

1,730,293. Heat Interchanger. Forrest C. Reed, San Francisco, Calif., and Frank A. Ernst, Somerset, Md. Filed Aug. 1, 1927.

1,730,298. Furnace. Walter E. Ryniker, Billings, Mont. Filed May 5, 1928.

Issued October 8, 1929

1,730,350. Apparatus for Condensing Hydro-Carbon Vapors. John E. Bell, deceased, Brooklyn, N. Y., by Lola R. Bell, executrix, Brooklyn, N. Y., assignor to Sinclair Refining Company, New York, N. Y., a Corporation of Maine. Filed Jan. 22, 1925.

1,730,385. Steam or Hot Water Boiler. Eugene A. Schenck, Kansas City, Kans., assignor of one-half to David E. Justus, Kansas City, Mo. Filed Mar. 15, 1926.

1,730,440. Heating and or Chemical Treatment of Liquids and Molten Materials by Direct Contact with Combustion Products. Stanley Cochran Smith, London, England. Filed May 4, 1925; and in Great Britain May 12, 1924.

1,730,461. Method and Apparatus for Applying a Fluid to Heat-Transfer Surfaces. David S. Jacobus, Jersey City, N. J., assignor to the Babcock & Wilcox Company, Bayonne, N. J., a Corporation of New Jersey. Filed July 5, 1923.

1,730,541. Boiler Efficiency Meter. Jacob M. Spitzglass, Chicago, Ill., assignor to Republic Flow Meters Company, Chicago, Ill., a Corporation of Illinois. Filed May 1, 1926.

1,730,569. Apparatus for Extracting Values from Coal and like Materials. Frank C. Greene, Denver, Colo., and Irving F. Laucks, Seattle, Wash., assignors to Old Ben Coal Corporation, Chicago, Ill., a Corporation of Delaware. Filed July 5, 1919.

1,730,570. Muffle Furnace. Frank C. Greene, Waukegan, and Otto H. Hertel, Chicago, Ill. Filed June 13, 1925.

1,730,602. Coke-Oven Apparatus. George T. Brunn, Pittsburgh, Pa., assignor to the Koppers Company, a Corporation of Delaware. Filed Mar. 3, 1928.

1,730,604. Pusher Ram for Coke Ovens. Carroll B. Collins and James A. B. Lovett, Pittsburgh, Pa., assignors to the Koppers Company, a Corporation of Delaware. Filed Jan. 29, 1927.

1,730,616. Stoker Mechanism. Nathan M. Lower and Paul A. Ketchpel, Pittsburgh, Pa., assignors by mesne assignments to The Standard Stoker Company, Inc., New York, N. Y., a Corporation of Delaware. Filed Feb. 26, 1926.

1,730,667. Furnace-Roof Construction. Mike Ross Lorino, Birmingham, Ala. Filed Sept. 21, 1928.

1,730,721. Handhole Cover. John J. Cain, Bayonne, N. J. Filed Nov. 18, 1919. Renewed Jan. 25, 1929.

1,730,739. Preheater. Arthur R. McArthur, Gary, Ind., assignor to American Sheet and Tin Plate Company, Pittsburgh, Pa., a Corporation of New Jersey. Filed Jan. 14, 1928.

1,730,776. Apparatus for the Precipitation of Particles Suspended in Liquids. Karl Torsten Ragnar Lundgren, Lund, Sweden. Filed Dec. 16, 1927; and in Sweden Dec. 22, 1926.

1,730,783. Preheater for Boiler Feed Water. Josef Reszkowski, Nitheroy, Brazil. Filed Feb. 19, 1925.

1,730,867. Locomotive Boiler. Peter Thomsen, Cassel, Germany, assignor to Schmidt'sche Heissdampf Gesellschaft m. b. H., Cassel-Wilhelmshöhe, Germany, a Corporation of Germany. Filed Apr. 20, 1923; and in Germany Apr. 22, 1922.

1,730,997. Method for Converting Solid Carbon into Liquid Hydrocarbons. Paul Danckwardt, Alhambra, Calif. Filed Jan. 13, 1928.

1,731,165. Method of and Apparatus for the Distillation of Carbonaceous Material. Otto H. Hertel, Chicago, Ill. Filed Mar. 15, 1924.

BRITISH PATENTS

Accepted July 26, 1929

316,341. Improvements in Pulverized Fuel Burner. Edward Charles Robert Marks, of 57 and 58, Lincoln's Inn Fields, London, W. C. 2.

316,242. Improvements in or relating to Pulverulent Fuel Burners. The General Electric Company Limited, of Magnet House, Kingsway, London, W. C. 2, and George Siddon Woollatt, of "Penthorpe," Bexley Road, Erith, Kent.

Accepted August 1, 1929

316,389. Method of Treatment of Coal Dust with a view to its Utilization in Burners. Lucien Liais, of 164, Rue de la Pompe, Paris, France.

316,402. Improvements in Stoker Tuyere Construction. Edward Charles Robert Marks, of 57 and 58 Lincoln's Inn Fields, London, W. C. 2.

316,416. Improvements in or relating to Electric Heating Boilers, Steam Generators and the like. Electrical Improvements Limited, of Carliol House, Newcastle-upon-Tyne, County of Northumberland, Lewis Colin Grant, of Wandsworth House, Heaton, Newcastle-upon-Tyne, County of Northumberland and Gerald Richmond Wilson, of Dalham, Southlands, Newcastle-upon-Tyne, County of Northumberland.

315,468. Improvements in Steam Boilers. Kyrle William Willans, of Dovaston House, Kinnerley, Oswestry, Shropshire.

316,466. Carbonization of Coal. Desire De Nagy, of 10, West Kensington Mansions, West Kensington, London, W. 14.

Accepted August 12, 1929

317,741. Improvements relating to Dust Separating Apparatus. British Rema Manufacturing Company, Limited, of Hubert Works, Highroad Well, Halifax, County of York, and Ludwig Kahler, of the Company's address.

Accepted August 14, 1929

317,341. Improvements in Mechanical Kilns. Balz-Erzrostung, Gesellschaft mit Beschrankter Haftung, of 4, Alsenstrasse, Gleiwitz, Germany, and Dr. George Balz, of Tubingen, Germany.

Accepted August 22, 1929

302,661. Improvements in Water Tube Boilers and similar Heat Interchangers. Compagnie De Fives-Lille, of 7, rue Montalivet, Paris, France, assignees of Rene-Victor-Stanislas Thery, of 25, Boulevard de l'Ocean, St. Nazaire, France.

310,833. Improvements in or relating to Regenerative Heating Systems. Milliken Brothers and Blaw-Knox, Limited, of Wellington House, Strand, London, W.C. 2, assignees of Waldemar Dyrssen, Sharpsburg, Pa.

317,631. Improvements in or relating to Steam Separators and like Apparatus. Walter Sydney Ackroyd Backhouse, of White Lodge, Hill Top, Wilmslow.

Accepted August 26, 1929

291,111. Improvements in Steam Generating Plants. Aktiengesellschaft Brown, Boveri & Cie., of Baden, Switzerland.

317,889. Improvements in or relating to Suspended Roofs for Furnaces and the like. Albert Reppman, of 150, Queen Victoria Street, London, E.C. 4

Accepted August 29, 1929

292,931. Process for Treating Coking Coal and the like with Smoke and Dust from Reduction Furnaces. Paul Louis Joseph Miguet, of St. Julien-de-Maurienne, France.

298,080. Coal Dust, Gas and Oil Burner for Constant Velocities of Ejection Under Variable Loads. Witkowitzer Bergau-und-Eisenhütten-Gewerkschafft, and Carl Salat both of Witkowitz, Mähren, Czechoslovakia.

300,921. Apparatus for Removing Dust from Currents of Gas. Arthur Stievenart, of 12, rue Philippe de Wolf, Boitsfort, Belgium.

317,952. Improvements relating to the Internal Heating of Ore Reducing Chambers and other Furnaces. Henry Edwin Coley, of 12a, Charterhouse Square, London, E.C. 1.

317,977. Improvements in and connected with Water Tube Boilers. The Stirling Boiler Company, Limited, of 32-33 Farringdon Street, London, E.C. 4.

318,082. Separation of Dust from Boiler Flue Gases. James Thomas Baron, of Wood Dale, Bells Chase, Great Baddow, Chelmsford, and Joseph Bernard Clarke of 210, Gloucester Terrace, Hyde Park, London, W. 2.

Accepted September 2, 1929

296,775. Improvement in Plants for Washing Coal and other Minerals. Antoine France, of 17, Quai St. Leonard, Liege, Belgium.

Accepted September 5, 1929

300,242. Improvements in and relating to Annealing Furnaces. International General Electric Company, Incorporated, of 120 Broadway, New York, assignees of Allgemeine Elektricitats-Gesellschaft, of Friedrich Kark-Ufer, Berlin, N.W., Germany.

306,394. Fire-Bridge. Rolfs Kohlen-Oxyd-Verbrenner Gesellschaft mit Beschraenkter Haftung, of Baumwall 3, Hamburg, Germany.

318,373. Apparatus and Process of Distilling and Burning Coal. Harry Septa Reed, of 436 Evergreen Street, East Lansing, and Ralph David Lamie, of 3757 Virginia Park, Detroit.

318,375. Improvements in and relating to Pulverisers. William Albert White, Prince Consort Road, Hebburn-on-Tyne.

318,394. Improvements in and relating to Superheating in High-Pressure Locomotives. Sir George Croydon Marks, of 57 and 58, Lincoln's Inn Fields, London, W.C. 2.